# SCIENCE



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## *THE IMPORTANCE AND THE PROMISE IN THE STUDY OF THE DOMESTIC ANIMALS.**

IT is believed that for the advancement of science, no better service can be rendered by those of considerable experience as teachers and investigators than to point out to their younger brethren lines of study and research which are, on the one hand, important, and on the other promising of results. I have, therefore, selected for the subject of this address before the section of zoology a plea for the study of the domestic animals. The young zoologist may rightfully ask the grounds for studying this heterogeneous, greatly modified series of animals. In the first place it must be confessed that for the animal kingdom as a whole it appeals mainly to a single one of the twelve phyla in the animal series given by Parker and Haswell—that is, to the vertebrates. The other eleven phyla—that is, the whole of the invertebrates except the arthropoda--are ignored. I wish to express very clearly and emphatically at the outset that the plea will not be made because the domestic animals seem to me alone worthy of study by zoologists, or that they are in all cases the best possible representatives of their group. It is most earnestly believed, however, that in the whole range of zoology no forms offer a greater reward for the study of the problems of life, especially in the higher groups, than the domestic animals. The importance of the study cannot be overestimated from a purely scientific standpoint, and certainly if the prosperity, happiness and advancement of the human race are put in the count the subject is of transcendent importance.

* Address of the Vice-President and Chairman of Section F, Zoology, of the American Association for the Advancement of Science, Columbus, August 21, 1899.

A glance at the tabular arrangement of the domestic animals will show where they are situated in the animal kingdom. In the great group of Invertebrates the two domesticated species—the Honey-Bee and the Silk-Worm—may be properly compared to minute islands in a great ocean. Among the Vertebrates, on the other hand, the domestic forms are represented in two of the six classes, viz.: in the Birds and Mammals, and where represented are among the most prominent and important members of the various orders:

DOMESTIC INVERTEBRATES.

The Honey-Bee (*Apis mellifica*).
The Silk-Worm (*Bombyx mori*).

DOMESTIC VERTEBRATES.

Class Aves—Birds.

1. **Natatores** { Goose (*Anser cinereus*). Duck (*Anas boschas*). Swan (*Cygnus gibbus*).
2. GRALLATORES—Waders (no domestic forms).
3. **Gallinaceæ** { Hen (*Gallus domesticus*). Turkey (*Meleagris americana*). Peacock (*Pavo cristatus*).
4. **Columbinæ**—Pigeon (*Columba livia*).
5. SCANSORES — Climbers (Parrots, woodpeckers, etc.). (No domestic forms.)
6. **Passeres**—Canary Bird (*Serinus canarius*).
7. RAPTORES—(Formerly the Falcon was in a sense domesticated).
8. **Cursores**—Ostrich (*Struthio camelus*).

Class—Mammalia.

(A) MONOTREMATA (Forms which lay eggs).
(B) MARSUPIALIA (Forms without true placenta).

ORDERS OF PLACENTAL MAMMALS.

1. EDENTATA—Armadillo, sloth, etc.
2. CETACEA—Whale, porpoise, etc.
3. SIRENIA—Manatee and Dugong.
4. **Ungulata** { Horse (*Equus caballus*). Ass (*Equus asinus*). Pig (*Sus scrofa*). Camels { *Camelus dromedarius*. *Camelus bactrianus*. } Sheep (*Ovis aries*). Goat (*Capra hircus*). Ox (*Bos taurus*). Elephant (*Elephas indicus*).
5. **Carnivora** { Cat (*Felis domestica*). Dog (*Canis familiaris*).
6. **Rodentia** { Rabbit (*Lepus cuniculus*). Guinea Pig (*Cavia cobaya*).
7. INSECTIVORA—Mole, hedgehog, etc.
8. CHEIROPTERA—Bats.
9. PRIMATES { Monkeys and apes. Man (*Homo sapiens*).

NOTE—In the table of birds the ordinal arrangement is that of Claus. It will be noted that five of the eight orders of birds have domesticated representatives. Among placental mammals three of the nine orders are represented, the order Ungulata containing the larger number and the most important representatives. A few forms in addition to those named in the tables have been, at some time, more or less completely domesticated.

With the personnel of the subject for discussion thus fairly before us, what has been, what is, and what is likely to be the influence of these forms in the rise and progress of knowledge in the broad field of zoology? Or more specifically, (1) What has been and what is likely to be the influence of the study of the domestic animals upon the doctrine of the evolution of organic forms? (2) What has the study of them contributed in comparative anatomy, embryology and physiology? (3) What has been the contribution in hygiene and preventive medicine? (4) And, finally, what should be their influence in theories of heredity and sociology?

If we would realize the value of the Doctrine of Evolution, let us imagine for an instant that this doctrine of 'orderly change' were eliminated from the knowledge of men!

To turn the zoologist back to the old notions of special and independent creation for each species or group of animals, would be like leaving the astronomer only the sun-god, and the angels to direct the planetary movements. No, it is now next to impossible to conceive of zoology struggling to comprehend the animal kingdom without this guiding principle. If similarity of form, color, structure and stages in embryology, function and even diseases are mere coincidences without further meaning, then, indeed, from a scientific standpoint, one

might as well spend his life and thought on Chinese puzzles as upon zoology. But that there is meaning and inspiration in the study of zoology requires no argument from me in this company, for on the altars of of this section still burns the sacred fire kindled by our absent members—Agassiz, Leidy, Cope, Allen, Marsh and a host of others who now 'see as they are seen, and know as they are known.' It is only for me to endeavor to point out some ways in which that study may be most productive.

If the doctrine of evolution has so illuminated the way, given meaning and point to the work which it never had before, it is pertinent to ask, to what are we indebted for the general belief in this doctrine? No better answer can be given than in the words of Darwin himself in the introduction to the 'Origin of Species:' "It is, therefore, of the highest importance to gain a clear insight into the means of modification and coadaptation. At the commencement of my observations it seemed to me probable that a careful study of domesticated animals and cultivated plants would offer the best chance of making out this obscure problem. Nor have I been disappointed; in this and in all other perplexing cases I have invariably found that our knowledge, imperfect though it be, of variation under domestication, afforded the best and safest clue. I may venture to express my conviction of the high value of such studies, although they have been very commonly neglected by naturalists." In a work published on this side of the Atlantic, the author, Professor L. H. Bailey, a member of our old Section of Biology, boldly faces those who, still doubting, say: "perform this miracle of changing one species into another before our eyes, and we will believe;" and says: "If species are not original entities in nature, then it is useless to quarrel over the origination of them by means of experiment. All we want to know, as a proof of evolution, is whether plants and animals can be profoundly modified by different conditions, and if these modifications tend to persist. Every man before me knows, as a matter of common observation and practice, that this is true of plants. He knows that varieties with the most marked features are passing before him like a panorama. He knows that nearly every plant which has been long cultivated has become so profoundly and irrevocably modified that people are disputing as to what wild species it came from. Consider that we cannot certainly identify the original species of the apple, peach, plum, cherry, orange, lemon, wine grape, sweetpotato, Indian corn, melon, bean, pumpkin, wheat, chrysanthemum, and nearly or quite a hundred other common cultivated plants. It is immaterial whether they are called species or varieties. They are new forms. Some of them are so distinct that they have been made the types of genera. Here is an experiment to prove that evolution is true, worked out upon a scale and with a definiteness of detail which the boldest experimenter could not hope to attain, were he to live a thousand years. The horticulturist is one of the very few men whose distinct business and profession is evolution. He, of all other men, has the experimental proof that species come and go." * * * Almost or quite as strong a statement might be made concerning domestic animals, as stock breeders and fanciers well know. But the more cautious may say, and have said: "This is the work of man's hands; man who ate of the forbidden tree and became like unto the gods, a lesser creator." Well, here again, ages before coming under man's dominion one of the domestic forms gave the final demonstration.

Those who have read the masterly argument of Huxley in the American addresses on evolution, the address of Marsh before the old natural history section of this

Association in 1877, and the address of Osborn before this section in 1893, know well the story. Starting with the generalized, five-toed forms of the basal Eocene in our own country, passing through many modifications and lateral experiments as they may be called, the five-toed form gradually became the four, three, and finally the one-toed modern horse, with its allies, the ass and the zebra. Thus long before the Coast Range was brought forth, while still the eternal hills were young, the primitive horses disported themselves in vast multitudes in our Western Territories; and it is believed that from this contient they passed to Asia, Africa and Europe, only to come back in these latter days to this so-called New World after making the circuit of the entire earth.

Among living forms perhaps no creature aided more in carrying conviction to the mind of Dawin himself, and to countless other people, than the common domestic pigeon. For most of the domestic animals it is usual to bring in a hypothetical, fossil type, so widely have the living forms departed from any living wild types, and so true to the domestic types do the offspring hold; but with the pigeon it is not uncommon that reversions to the parent form occur, and even in the most modified forms reversions occur, so that there is substantial agreement that the parent stock is the wild rock pigeon (*Columba livia*). That there should be reversions in some forms is astounding, for even the number of vertebræ has become changed by domestition.

If, then, this study of domesticated and cultivated forms has thrown so much light upon this great subject of evolution as the method of nature, is there not promise of rich return for future study? And there is need of future study, for only a beginning has yet been made in this great field.

Let us now turn from Evolution to discuss for a few moments the help which the domestic forms have given to Anatomy, Embryology and Physiology.

If one asks of what animals the structure is known in the greatest detail it must undoubtedly be answered that the structure of man has been most thoroughly explored, then come the domestic animals, especially the horse, dog, cat and rabbit. Much of this work was done before the doctrine of evolution illuminated the way and gave meaning to rudiments or vestiges and to homologies. Still it must be said, in truth, that the older zoologists, with a rare insight, discussed large questions of homology, and recognized at bottom the real relationship of many different forms. It was, however, only the philosophical and far-sighted few who did so. The majority of anatomical work was done for its purely practical bearing on medicine and surgery. It thus happened that human anatomy exerted a powerful influence, indeed, so powerful that names were carried over into the invertebrates, for parts which could hardly, by the greatest stretch of imagination, be homologous with the structures in man from which they were named. If there was any relationship it was of function or analogy rather than that fundamental kinship expressed by homology. Thus the legs of a horse and a spider are for the same general purpose. They are analogous, not homologous organs. Therefore, in many cases in the older morphological work one should not be deceived by supposing that there was any real insight into the phylogenetic relationship of the two forms whose parts were similarly named. While there has been a great tendency to designate parts alike which have only a fancied or analogous relationship, there has been a more harmful tendency to ignore real relationships. Only purely practical ends have been too often in view, and the real kinship of forms as little known as cared about.

What is urgently needed at the present time in comparative anatomy, especially that relating to the domestic animals, is a thorough revision in the light of this last half of the 19th century; then the student, whether especially trained in human, veterinary or comparative anatomy, could pass from form to form and far more easily correlate truly homologous parts, because they would bear the same designations; and he would thus be led to see and appreciate the true kinship, although at first sight there might appear to be only unlikeness.

If any one cannot see the force of what has been said, or does not feel any lack in the present conditions, let him think of the different joints in the limbs of man, horse, dog, chicken and honey bee; or let him ask some one who knows the animals well, but is untrained in advanced anatomy. I believe that such an experience would convince any open-minded inquirer that like designations for homologous parts are desirable; and, secondly, he would be filled with increased admiration for the view of organic nature which points out the significance of a real likeness in what appeared in the beginning so utterly diverse. Here then is work which stands ready for the ablest zoologists.

In Embryology and Physiology the domestic animals have always furnished the greatest amount of information, as one can satisfy himself by consulting any treatise upon these subjects, although 'Human Embryology,' 'Human Physiology' may be printed on the title page. Who did not get his start in embryology by studying the development of the chick, the dog, cat, rabbit or guinea pig? And in physiology students are almost equally dependent on the dog and rabbit. What is known in these fields is but a drop in the bucket, and as the domestic animals have contributed the greater part of that drop, so will they be called upon to fill the bucket to the brim. And what a splendid outlook there is at the present time. New discoveries in physics, like the X-rays, make possible advances in physiology. Perfection of technique in microscopy makes advance in embryology possible. Contemplate the opportunity and the promise for a moment. There is not a single treatise in any language which deals adequately with the embryology of the domestic animals, and the only one in English, the only one usually studied by the veterinary student, is hopelessly bad and antiquated. If one glances at the tables showing the zoological position of the different domestic animals he must be impressed with their wide distribution in the animal kingdom and their representative character. What an opportunity is here for work in comparative embryology! It is coming to be felt that the embryology of the present day is very inadequate in that, while it professedly deals with the entire development of the individual, it really devotes its main energy to the earliest stages and to the very beginnings of the organs. The complete ontogeny of the individual must go further than this and trace the development from the ovum through all the life stages to old age and death. It is only among the domesticated forms, in the higher groups at least, that abundant material under complete control, is at command, without very great expense. Abundant material, with full knowledge concerning it, will be required for satisfactory monographs in the future.

For students, material in great amount at a merely nominal cost, and without sacrificing animals especially for the purpose, may be had at every large abattoir; and every village slaughter house wastes more than enough embryological material every year to supply the aspiring young zoologists in its precincts. That this material is being utilized is evident from the admirable papers upon em-

bryological subjects and from the laboratory announcements of Harvard, Johns Hopkins and many other centers for investigation and sound embryological instruction.

It was intimated above that the pressing need of zoology to-day is complete knowledge of some typical forms, such, for example, as are represented by the domestic animals in the avian and mammalian classes. This thorough knowledge is needed rather than more of the bits and patches from the entire animal kingdom. It is certainly true that morphological knowledge at the present day is too much like a crazy quilt. This every investigator finds to his cost when he wishes to carry a research beyond the most elementary stages. What is needed, then, is concentration—complete knowledge, so far as possible, of each form investigated; and this knowledge must compass the entire life cycle. As also stated above, embryology has, and perhaps properly, concerned itself largely with the beginnings of the organisms and their organs. But in so doing the later but no less important changes have been left almost untouched. Ontogenetic development after birth is of the profoundest importance from all biological standpoints. In some ways a knowledge of how the new-born becomes an adult is certainly of profounder interest than how an egg becomes a new-born animal. A few years ago the agricultural experiment stations, especially those of Wisconsin and New York, wished to answer, so far as possible, the question of how to obtain the best nutrition and growth to render animals most satisfactory as food and thus, also, the most profitable in the market.

There arose questions concerning the changes in muscle, if any, in passing from youth to maturity and from maturity to old age; from a condition of leanness to fatness. Here were some very pertinent questions which only a biologist could answer, but at that time many of the questions were enshrouded in darkness. But during the present year several investigations bearing upon these points have been published. Every one knows that the muscles increase in size as well as in strength in a growing animal, and also that they increase in size and strength in an adult if properly exercised. But who would have been prepared to expect that in this increase in power and size of the whole muscle the individual fibers of which it is composed would actually decrease in number? This brings us to the fundamental question of the mechanism and the structural changes by which youth and maturity are merged into old age and decay? If you will read the suggestive address of Dr. Minot given at the Indianapolis meeting in 1890, and the papers of Hodge on the changes in nerve cells from childhood to senility, you will gain a notion of the work to be done upon the post-embryonal ontogeny, and the rewards to be gained by the faithful, clear-brained investigator.

I cannot leave this part of the subject without reminding you again of the brilliant part the paleontology of the horse has played in zoological science, and to express the belief that its embryology, when thoroughly worked out, will play an equally brilliant one. At present this embryology is known only in fragments. Why should there not arise in this boundless western world, in the land where the earliest horses appeared, some embryologist who, with the cheap and abundant material, should work out this problem with completeness? Next to man himself there is probably no animal in which the civilized world is more profoundly interested. To trace in the growing embryo not only its own life history, but to gather as many and clear glimpses as possible of its race history, would, indeed, be an inspiration. Enough

is already known to make one sure that the field is worth working and that the harvest is certain. Almost as much might be said for some of the other domestic animals. And why should not some of this splendid work be done in America? This was the original home of the horse, of representatives of all the groups of domesticated animals, and every summer brings from its boundless treasures ever new and more marvelous forms. I believe that the time will come—indeed, that it is at hand—when zoological science, yes all science in America, will go forward with the giant strides which have already characterized her inventive and industrial history.

So far this address has been practically limited to the higher vertebrates, but I would not remain wholly silent upon the great phyla of invertebrates. The honey-bee and the silkworm should not be passed by without a word. Their history, like that of most of the domestic animals, is shrouded in darkness, but they are still with us, calling forth from each generation renewed interest and admiration. They, too, offer problems for the biologist, and deserve his attention. For example, take that great question of apparent voluntary parthenogenesis with the bees. What is the mechanism by which fertilized eggs become queens or workers and unfertilized eggs become only drones? Is this very general belief really true? If true what are the differences in the course of development in the eggs in the two cases? Then in Physiology what a multitude of problems the bees propound? Why will a special form of food cause an egg to develop into a queen instead of a worker? How can the workers change honey into beeswax? How can a mere blind pouch serve the purposes of digestion and excretion in the larva? For answering all these questions and many others the honey-bee is admirably adapted. One can keep the swarm constantly under his eye, and he can control, so far as necessary, the actions of the bees; there is abundance of material which may be had at all stages of development. Indeed, with the hundreds of thousands, perhaps millions, of insect species yet to discover and describe, and all these questions of structure, function, embryology, transformation, histolysis and redevelopment to answer, it looks as if the entomologist would not be compelled to sit down and sigh for new worlds to conquer for some time yet. And if I may be allowed to carry over my convictions from the vertebrates to the invertebrates, I believe that zoology would be far more advanced if a million or two species of insects were left undescribed and the enthusiasm and devotion of the entomologists—and no class of zoologists are more enthusiastic and devoted—were directed toward the elucidation of the entire life cycles of a few typical forms, and the structure, function and embryology of these were worked out as completely as modern knowledge and method would allow. Then there would be some standards of comparison to facilitate the work on the infinite number of forms still uninvestigated. From the monographs on the embryology and morphology of insects which have appeared during the last few years one cannot help feeling that this fascinating field will soon claim a multitude of students, and that none need go away empty-handed.

In Preventive Medicine and Hygiene the domestic animals have, as in so many other fields, served as the basis for study and investigation. To appreciate their importance one has but to recall the fact that at the close of the last century Jenner's application of cowpox as a protection against smallpox has led to an almost complete expulsion of this once dreaded scourge from civilized lands. Or to refer to the memorable investigations of Pasteur begun in 1866 for the amelioration of the condi-

tion of the silk industry of France. He saw and pointed out, with the greatest clearness, the importance of cleanliness, fresh air and good food for the avoidance of degeneration and disease in the silkworms. Are not fresh air, cleanliness and good food the very foundation stones of hygiene for all animal forms? In the silkworms, also, Pasteur found causes for disease in the microscopic organisms which infested their bodies, and in some cases at least this cause appeared to pass from one generation to the next through the eggs. What this study of Pasteur upon the diseases of silkworms, upon anthrax in the domestic mammals upon fermentation, did for surgery is thus expressed by Lister, the recognized father of antiseptic surgery, at the jubilee celebration of Pasteur: "Truly there does not exist in the entire world any individual to whom the medical sciences owe more than they do to you. Your researches on fermentation have thrown a powerful beam which has lighted the baleful darkness of surgery, and has transformed the treatment of wounds from a matter of uncertain and too often disastrous empiricism into a scientific art of sure beneficence. Thanks to you, surgery has undergone a complete revolution, which has deprived it of its terrors and has extended, almost without limit, its efficacious power."

In our own and in other countries what untold loss has come from 'Texas Cattle Fever?' The working-out of the biological relations of that disease, it seems to me, is one of the most brilliant pieces of scientific investigation which has illuminated this truly luminous end of the 19th century. With all the knowledge accumulated since Pasteur's investigations on the silkworm diseases to serve as guides and to give suggestions, it took one of the foremost pathologists which our country has produced (Dr. Theobald Smith) three years to bring the investigation to a demonstration. And little wonder! For instead of the previously known simple relations of microbes to disease, the way was round about and involved two generations of animals and two species. Furthermore, the germ of the disease was not a bacterium or fungus, easy to cultivate on artificial media, but one of the sporozoa for which no artificial culture medium has yet been devised. The story is briefly as follows: Cattle ticks (*Boophilis bovis*) suck the blood of animals in which the Texas-fever germ is present. The germs enter the eggs of the ticks and thus infect the next generation. This new generation of ticks attach themselves to other cattle and introduce into their blood the disease germs which are carried over from a previous generation. And so the mutual infection goes on in a vicious circle from generation to generation. The direct human interest, outside the economic one, which this investigation has is the suggestion and the accumulating proof that malaria in man is transmitted in practically the same manner by mosquitoes. Truly the living hypodermic syringes are to be feared as well as execrated.

Thus hardly a triumph in medicine has been won without substantial aid from the domestic animals, and it is believed by the acutest minds engaged in the great work of ameliorating the sorrows of the world caused by preventable disease and premature death that we are now only on the threshold of discovery. Is not the fact that the discoveries in medicine and hygiene in the past have been so dependent upon the domestic animals sufficient guarantee that future discovery will be likewise dependent upon them; and as human beings are so closely linked with the domestic animals in economics, in hygiene and in promised avoidance of disease, is there not abundant reason why the veterinary profession should be elevated and become a true unit in university life, a close colleague

with the profession of human medicine; and that human medicine in turn should reap even greater good in future by a more thorough appreciation and study of comparative medicine?*

At this time, when the dawn of the 20th century is already in the sky, the biological problem most important to the animals, and to the human race in its aspirations, is the problem of heredity. What is its mechanism, what light does it throw upon the chances for preservation from degradation, and for elevation to exalted manhood? Organic evolution has shown in the clearest manner that 'descent with modification,' in order to meet the requirements of the environment, does not, by any means, signify in all cases what is commonly meant by the term progress. Consider the mental and physical condition of parasites. They have descended literally, and with the profoundest modifications. Look at the serpents and the partly limbless forms of the ocean. In their descent they progressed toward fitness for their environment, fitness to make the most and best of the life they have to lead; but this is not the modification desired in human descent. The Utopia for human society is where there is abundant food for all, congenial labor for all, education and amusement for all, every one to work out in its fullness his own individuality and at the same time serve the common weal. What lessons do the domestic animals give upon this? That 'like produces like' is a generalization believed in by every one, and sufficiently supported by every-day observation. Equally true and general is the statement that 'like produces unlike'—that is, no offspring is exactly like its parents, and no two offspring are exact duplicates. While the race type is persistent, individual modifications are infinite. In this likeness and still unlikeness between offspring and parent is the hope and the despair of mankind. The hope because every horticulturist, every stock breeder and every parent hopes that the offspring will be unlike, but that the unlikeness will be an improvement. The despair because unlikeness is just as liable to take the trend of the undesirable qualities and intensify them. With the lower animals the undesirable modifications may be eliminated, must be eliminated, or the race will deteriorate. In the human family the problem is equally plain, but infinitely more difficult of execution. How can the brood of criminals be avoided and the sturdy and right-minded possess the earth?

If one would see how social theories have worked themselves out successfully the domestic animals again furnish models, models in which theory is no longer theory, but fact under which thousands of generations have lived, flourished and passed away. The most perfect states are found among the social insects, foremost of which are to be mentioned the honey-bee. This society, which man has had under domestication so many thousand years that the beginning has been forgotten, has won the admiration of the world, and poets and philosophers have immortalized it with their words. What could appear more perfect? Each member of the society is apparently free, and each labors for the common good. Truly it seems an ideal state, but to attain this ideal state queens must kill their sisters or be killed by them; thousands must be relegated to ceaseless toil, and kings exist but for a day. This perfect state consists only of a queen-mother and thousands of sexless slaves. All exist, not

*For further discussion of the relations between human and comparative medicine, see for Comparative Medicine, Dr. James Law's address at the inauguration of the New York State Veterinary College, September 24, 1896.—*Veterinary Magazine*, September, 1896. For Human Medicine, see Dr. Charles S. Minot's Yale University Medical Commencement Address, June 29, 1899.—SCIENCE, July 7, 1899.

for their own individual pleasure, improvement or happiness, but only for the community. If socialists will study this and other examples of states which have resolutely worked out the social problems to a successful finish they will perhaps get an inkling of how far off is the realization of all Utopias, of even the noble aspirations of our own National Declaration of Independence. Their realization is far off and difficult or impossible because the struggles of individualism are never compatible with perfect socialism. It is not possible to serve both the state and the individual with one's whole power. If there is partial service, as there must be in human society, neither the state nor the individual will have the most perfect development. The parallelogram of forces will give a resultant to be sure, but so far this resultant has proved a tortuous and unsatisfactory line instead of the perfect form of beauty dreamed of by the enthusiasts.*

In this brief review I have tried to show a few ways in which the study of domestic animals has thrown light on the problems confronting mankind in his social ideals, in preventive medicine, in physiology and hygiene, in embryology and comparative anatomy and in the doctrine of the evolution of organic forms. The attempt has been made to show that, with the higher forms at least, that is the forms most closely related to man, and with whose destiny his own economic, hygienic and social relations are most closely interwoven, the domestic animals have in the past and promise in the future to serve the best purpose because of the abundance of the material in quite widely separated groups of animals which long have been and still are under greatly differing conditions and surroundings; and, finally, because this material is plentiful and under control, and thus may be studied throughout the entire life cycle.

If any one is repelled from the study of domestic animals because they have been greatly modified by their so-called artificial surroundings in the company of man, I would remind him that man is also a part of nature, and that the modifications due to his action simply illustrate, in a somewhat definite and determinable degree, the plasticity of the forms under his control, and thus give the clearest and most undeniable proof of the capability of change in response to environment and selection. Furthermore, any wild form chosen for investigation has likewise departed widely from its primitive state, under the stress of changed and changing environment and a selection somewhat different but none the less severe. It is also contended that the knowledge of the environment of these domestic members of the zoological family for so long a time has been of the utmost help to many of the ablest workers, as one can infer from the quotation from Darwin in the earlier part of this address. There has been and still is too great a tendency in biology to study forms remote and inaccessible. This is, perhaps, partly due to the fascination of the unknown and the distant, and the natural depreciation of what is at hand. But study of these supposedly generalized types has proved more or less disappointing. No forms now living are truly primitive and generalized throughout. They may be in parts, but in parts only. The stress of countless ages has compelled them to adjust themselves to their changing environment, to specialize in some directions so far that the clue through them to the truly primitive type is very much tangled or often wholly lost. Indeed, every group is in some features

*The reader who is interested in sociology is advised to read the admirable articles of Mrs. Anna Botsford Comstock on Insect Socialism in *The Chautauquan* for 1898, Nos. 4, 5 and 6; also Shaler's 'Domesticated Animals,' for their influence in civilization.

primitive. Even man himself is one of the best forms to study the limbs upon. As expressed by one of my colleagues (J. H. Comstock) in his papers upon phylogeny, the unraveling of the mysteries of 'descent with modification' in their entirety cannot be worked out in a single form or group; the puzzle must be spelled out part by part, and one group will serve best for one organ and another for another.

As any complete study requires much material at all stages the higher forms must be of the domesticated groups, or wild forms must be practically domesticated for the time being to supply the material.

It may be objected, also, that in the investigation of domesticated forms sordid interests will play too prominent a part. No doubt, to the true scientific man the study of zoology for its own sake, that is for an insight into the fundamental laws of life, is a sufficient incentive and reward. Judging from the past, the study of the domestic animals in any other way than in a scientific spirit and by the scientific method will prove barren, but studied in that spirit and by that method the result has always justified the effort, and has thrown as much, if not more, light upon biological problems than an equally exact study of a wild form.

Therefore, while purely practical ends can never supply the inspiration to true scientific work, still surely no scientific man could feel anything but happiness that his work had in some ways added to the sum of human well being. Perhaps no one has expressed so well the sympathy of a scientific man with his fellow men as Pasteur in the preface to his work on the silkworm diseases: "Although I devoted nearly five consecutive years to the laborious experimental researches which have affected my health, I am glad that I undertook them. * * The results which I have obtained are perhaps less brilliant than those which I might have anticipated from researches pursued in the field of pure science, but I have the satisfaction of having served my country in endeavoring, to the best of my ability, to discover a remedy for great misery. It is to the honor of a scientific man that he values discoveries which at their birth can only obtain the esteem of his equals, far above those which at once conquer the favor of the crowd by the immediate utility of their application; but in the presence of misfortune it is equally an honor to sacrifice everything in the endeavor to relieve it. Perhaps, also, I may have given young investigators the salutary example of lengthy labors bestowed upon a difficult and ungrateful subject."

As a final word, let me summarize this address by saying: However necessary and desirable it may have been in the past that the main energy of zoologists should be employed in the description of new species and in the making of fragmentary observations upon the habits, structure and embryology of a multitude of forms, I firmly believe that necessity or even desirability has long since passed away, and that for the advancement of zoological science the work of surpassing importance confronting us is the thorough investigation of a few forms from the ovum to youth, maturity and old age. And I also firmly believe that, whenever available, the greatest good to science, and thus to mankind, will result from a selection of domesticated forms for these thorough investigations.*

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* If the young zoologist wishes to get a clear notion of the meaning and value of 'species' in modern biology he is recommended to read Dr. Farlow's address in last year's Proceedings; also Dr. D. S. Jordan's 'Kinship of Life' in his 'Footnotes on Evolution,' and Professor Bailey's chapter on 'Experimental Evolution Amongst Plants' in his book on the 'Survival of the Unlike.'

## THE PROGRESS AND PROBLEMS OF PLANT PHYSIOLOGY.*

THERE are some subjects of whose content and extent most educated people have fairly accurate conceptions, though they may not appreciate the significance of the numerous problems which those who carry forward research are attacking. Literature and history number their appreciative amateurs by thousands. Even such sciences as astronomy and chemistry receive a fair measure of popular approbation and are widely appreciated.

Unhappily this is not yet the case with botany. By even the limited number who think they know of what it treats, it is frequently misunderstood and consequently undervalued. To most mature people it is hardly more than a name for a dilettantish dissecting of flowers, for which an apprenticeship of memorizing troublesome technical terms must needs be served.

It is easy to discover why this is so. It has resulted from the mistaken ways of presenting the subject to elementary pupils. But the difficulty of correcting the misapprehension is not decreased by a knowledge of the way in which it has arisen. We can only rely upon the gradual substitution of better ideas in the newer generation by means of more adequate instruction, and on the occasional popular presentation of more accurate information. For the former we may look to the schools, which are rapidly changing the scope of their teachings. The latter, however, should be undertaken by specialists, as a matter both of duty and of privilege. Popular accounts of plant phenomena may be accurate without being dull, interesting without being sensational, and attractive without being sentimental. But we can expect these characteristics only in properly qualified writers whose scientific training has been sufficient to kindle their enthusiasms and quicken their energies—without spoiling their English. Such books, in considerable number, have been appearing lately from American writers. May their tribe increase! As books of this kind are multiplied we may hope for an increasing appreciation of the science of botany both educationally and economically.

When the general subject has been so misapprehended, what can be expected regarding one division of it? The experimental study of the physiology of plants is not new. Hales more than a century ago carried out such accurate experiments that they are quoted to-day. But even to fairly-educated people the word physiology, conjoined with plant, conveys no definite idea. 'Physiology' we studied at school; is it not that hybrid of human anatomy and hygiene, with barely enough real physiology to salt it, which is inflicted upon immature youngsters, to the accompaniment of lurid lithographs of an inebriate's stomach? But what can 'physiology' have to do with plants that have no teeth to decay, stomachs to ulcerate, or eyes to become myopic? And so it comes about that one must explain to the average man that plants are really alive, that they work and rest, that they are sensitive to what goes on around them, and that they have established relations with their plant and animal neighbors. How they do these things and how their activities underlie those of all other living beings, even man's, lies within the compass of this branch of the science of botany.

But to such a company as this it is not necessary to set forth in detail the province of plant physiology or to justify its rapid introduction into institutions of higher learning. While Cæsalpino and the schoolmen argued vainly about the location of the 'soul' of plants, it was the growing

* Address of the Vice-President and Chairman of Section G, Botany, of the American Association for the Advancement of Science, Columbus, August 21, 1899.

dissatisfaction with the empty reasonings of such scholastic philosophy that drove men to observe the phenomena of nature. Thus real physiology had its birth in the last half of the seventeenth century, only a little later than the other natural sciences. It is, however, only in comparatively recent years that plant physiology has become established upon a firm experimental basis and thus fitted to take its proper place among the sciences offered in university curricula. Its real and vigorous growth has been measured by scarcely four decades. Among the countless results of the rejuvenation of biology wrought by various cooperating causes about the year 1860, may be enumerated the rise of plant physiology. One of the first evidences of this renascence was the publication in 1865 of Sachs's *Handbuch der Experimental-Physiologie*, the first volume which gave any comprehensive and clear view of the phenomena of plant life.

From that day to this, with increasing vigor, Sachs's countrymen have been prosecuting researches into plant doings and guiding many students in their maiden investigations. French, Austrian, Italian and Russian students have also made notable advances. On the continent a few great centers of physiological research have been developed, like Würzburg, Tübingen, Leipzig, Bonn, Berlin, Vienna, Prag and Paris. Great Britain has made a notable beginning at three of her great university centers.

But in this country the specialization which alone makes possible the effective development of a subject, has been slower in coming, and it is scarcely a decade since physiology began to have any considerable attention. Five years ago (I speak by the card) one could count on the fingers of one hand the colleges which offered any but brief lecture courses in plant physiology, and the number giving even lecture courses was less than 4% of the total number of colleges. I am sure that many in this audience would be surprised were I to recite the long list of prominent institutions which gave no physiological courses—*some even no botany*. In late years many have made a beginning in the way of demonstration and lecture courses, but the number with even fairly equipped physiological laboratories is still few. Indeed, there are to-day not twenty-five institutions of higher learning in the United States which offer laboratory instruction in plant physiology, even in an elementary way, and still fewer which give opportunity for as much as a year's work. Graduate work in physiology, if the Graduate Handbook for 1898–9 may be relied upon, is now offered only at Barnard, Chicago, Columbia, Harvard, Michigan, Minnesota and Pennsylvania.

The development of centers of physiological research is therefore a matter of the future. It cannot be long delayed, however, for there is noteworthy energy in the advancement of this subject in several of the stronger institutions.

To the professional botanists, who are especially concerned in the advancement of the science, it would doubtless be of some interest should I take this opportunity to recapitulate the investigations which have been most fruitful of progress in the past decade. But the field is so vast, and work is being so vigorously prosecuted, that I should despair of being able, within the limits custom sets, to present adequately the march of our knowledge of plants within the last decade. To such a task, moreover, my own knowledge would be wholly inadequate.

Therefore, instead of presenting a summary of so extensive an investigation, I choose rather to confine my attention to the physiological aspects of botany, and in this field to endeavor to bring before you a conception of the general *trend* of investigation, without any endeavor to mention the work of individuals or even the important isolated

researches which may be the starting points of new lines of progress. At the same time I shall seek to indicate what I conceive to be fruitful lines of study and shall direct attention to some of the unsolved problems which still confront the physiologist.

### PHYSICAL CHEMISTRY.

The physiologist is dealing with material phenomena as manifested by living things. Physiology is, therefore, chiefly the application of the knowledge of chemistry and physics to the phenomena of life. It follows that the physiologist must be familiar with the laws deduced by chemists and physicists from their study of matter which is not under the influence of life. He needs to be equipped with the best physical and chemical knowledge of the day. Because of a want of such training reproach has often fallen upon physiology in the past. Inattention to these underlying sciences has led to divers fantastic explanations of phenomena—explanations forbidden by the fundamental facts of chemistry and physics. Compelled thus to rely on advance in other sciences for the possibility of progress in their own, physiologists welcome with the brightest anticipations the rapid growth and development of that field in which chemistry and physics merge—physical chemistry. There is much, it is true, with which its students concern themselves that does not touch directly the activities of plants. But some of its subjects are of the most intimate concern to physiologists.

*Solutions.*—This is notably the case with the comparatively recent coordination of long known facts and late discoveries into clear and definite laws of solutions. In no condition, outside and inside the plant body, does matter play a more important physiological rôle than in a state of solution in water. The prevalence of a cellulose wall, jacketing the protoplasm of their cells, is probably the most characteristic mark of plants. This membrane precludes the entrance into the body of any substance not in solution, whether originally solid or gaseous. Thus the behavior of solutions is of fundamental importance for the absorption of foods by the colorless plants and of the raw materials out of which the green plants can make foods.

The cellulose wall has been adapted by plants to subserve a function unknown in the animal body, namely, turgor. Only a knowledge of solutions enables us in a measure to understand the existence and regulation of turgor. The solutions enclosed by the semipermeable protoplasmic membrane of the living cell are rarely or never the same as those outside the plant or in paths of water conduction. Such a condition establishes at once a movement of water into the cell and develops a definite amount of hydrostatic pressure, equivalent to the osmotic pressure of the dissolved substances. Thus, by a figure, it is said that the osmotic pressure of the internal solutions pushes outward the protoplasm, backed by resistant but elastic wall, which stretches until its elastic resistance balances the osmotic pressure. If the cell be one of a group the cohesion and turgidity of the cells surrounding any one resist its enlargement. Thus all the cells of a turgid mass of tissue bear firmly against one another, and this condition is of great importance in maintaining the form of young parts in which as yet no mechanical tissues exist. Turgor has its influence also in regulating the diffusion of water vapor through the stomata, in transfusing liquid water through water glands, in certain forms of secretion, and so on. So important is turgor that special salts seem to be provided to maintain it at a normal point. Its relations to growth also are unquestionably of prime importance, but we are not able at present to interpret these relations satisfactorily. Although the statement is

generally made that turgidity is a prerequisite for growth and regulates it, there are some strong reasons for thinking that the relation is rather the reverse, and that growth regulates turgor.

Pathological changes may also be brought about by abnormally high osmotic pressure, a notable instance being furnished by œdema of various organs, especially leaves. In such a case, turgor seems to distend the cell walls extraordinarily, and to act as a stimulus on growth, causing a local hypertrophy characterized by bladdery tissues.

For interpreting all these processes, most fundamental for nutrition and growth, the new knowledge of solutions furnishes invaluable aid. This theory, developed mainly within the last decade by the labors of Pfeffer, Van t'Hoff, Arrhenius, Ostwald, Raoult, and others, looks upon a substance in solution in water as essentially a gas. Its molecules are freer to move than they are in the solid state because of their relations to the molecules of water. These, at the same time that they make mobility possible, obstruct the movements of the solute, so that the molecules of the latter are not nearly so free to move as the molecules of a gas. Thus enormous pressures are necessary to move the solute through the solvent or to remove its molecules from it. Many demonstrations establish firmly the fact that the molecules of solutes exhibit the well-known laws of gases. This general applicability of the fundamental laws of gases to solutes has made evident the proper basis of comparison between solutions of different compounds. For many years, and for some years after a proper knowledge of physical chemistry would have led to their abandonment as not comparable, physiologists were comparing the physiological action of percentage solutions or solutions of definite specific gravity, in ignorance that this was like comparing the action of one gas at atmospheric pressure with that of another at 10 atmospheres pressure. Henceforth, we must deal with equi-molecular solutions if a comparative knowledge of physiological action is sought.

A further study of the behavior of solutions has made us acquainted with the fact that when water solutions which conduct electricity, *i. e.*, electrolytes, are of less than a certain concentration, the solute undergoes partial dissociation, no longer existing alone as a definite chemical compound. A certain amount, depending on the concentration of the solution, is broken up into electrically charged part molecules or ions, which behave osmotically as molecules and increase the osmotic pressure of the solute. Moreover these ions exert a very marked physiological effect upon the protoplasm. Certain ions are extremely injurious, inhibiting the activity of the protoplasm and resulting in death. Poisons, so called, produce a similar result. It is possible that by a study of ionic action we may obtain a more accurate idea of what actually happens when living matter dies by 'poison.' It would be surprising were there not a considerable diversity in the actual effects of various 'poisonous' agents.

Again, certain ions have a less marked physiological action, which is designated as stimulation, calling forth corresponding change in the activity of the protoplasm. Unquestionably many of the peculiarities of growth and development of an organism are responses to the action of ionic stimuli, but of these practically nothing is yet known. Certain human sensations have already been shown by Kahlenberg in his investigations on taste to be due solely to the action of definite H and OH ions. In no organisms is there so good an opportunity as among plants to determine precisely how these factors, always acting in complex combinations, effect the modifications of form and function that constitute adaptation to external conditions.

Studies of this kind have barely begun. Kahlenberg and True were the first to establish the poisonous action of ionic hydrogen in solutions of certain acids and salts. A few other observers have attacked similar problems, but the field is hardly yet explored; it has not been at all cultivated. The relations are complex, it is true, and their unraveling will not be easy; but surely there are rich harvests for the patient worker.

In the light of the modern theory of solutions, it is essential that the whole field of root absorption be reexamined. Dilute solutions of the soil must surely be electrolytically dissociated in large measure, and this fact doubtless stands in intimate relation to the entrance of solutes into the plant. In the absence, at present, of complete experimental demonstration of the behavior of these substances, we are compelled to rely largely upon theoretical probabilities. Interesting possibilities, however, present themselves to the speculative worker and point out various directions in which investigation may be fruitful.

*Energy.*—One of the directions in which physical knowledge is now extending, but in which it is still so imperfect as to leave much to be desired, is in the understanding of the forms and transformations of energy. But the physiology of plants has not yet made use of all the knowledge that is available in this direction. Though in the past decade we have had some important researches, there yet remain great gaps in our knowledge of the income of energy to the plant and of the ways in which it is utilized. I may here indicate only a few of these gaps in our knowledge.

While it is easy to calculate the potential energy of the foods absorbed it is not easy to determine how much of the energy is available, in what form it is released and what changes it undergoes, as it is used by the plant.

We know that heat is one form of energy which is constantly affecting the organism, and we speak of certain temperature limits as one of the essential conditions for life. But what does that mean? Why is it a condition of life? Is it merely because the necessary chemical changes can only occur within certain limits? If so, what does *this* mean? Does it mean that the radiant energy which imparts to us the sensation of heat must be acting upon the molecules of the various chemical compounds ere they are capable of enough lability to afford the living protoplasm opportunity to push them over, so that they fall into simpler compounds, or to lift them to a higher level of complexity and to greater instability? If heat does not merely increase chemical instability, is life possible within certain limits of temperature because there is pouring into the organism a supply of energy which the protoplasm may utilize in directer fashion to do the work necessary to existence?

What is the source of energy for the colorless plants which assimilate the simpler foods? It is almost inconceivable that they can produce proteids out of the carbohydrate and nitrogen compounds with which they can be supplied without needing a considerable amount of energy besides the potential energy which reaches them in the foods they absorb. If there is no direct supply of radiant energy, it looks very much as though these plants had acquired the long-sought power of lifting themselves by their own boot straps. Yet if radiant energy, either as light or heat, is utilized by them, we know nothing of it at present. Or is it the energy of the $O_2$ absorbed for respiration which accounts for the extra work done? The data are not at hand to determine the correct answer to these questions. General statements abound, and to many it may seem that all this is known, since it is often dogmatically settled in text-books. Yet in reality we must have

exact measurements of the amounts of energy involved—a thing not yet accomplished—before we can be said really to know whence plants derive their energy and what heat means for them.

Even the case of the green plants is not at all clear. That they construct their own food in great measure is certainly true. That they do this by using absorbed radiant energy of the quality which gives us the sensation *light* is well known. But it is by no means clear, in terms of chemistry and physics, how this is done, or even what measure of the absorbed energy is utilized. Measurement, indeed, is difficult, yet quantitative results are necessary before we can be satisfied that we know what is happening when the leaf makes food.

Finally it may be said that little is yet known of the energy relations in the processes of growth. Here, since we must deal wholly with internal release and utilization of energy, investigation will be most difficult and uncertain.

*Stereochemistry.*—The decade that is passing has witnessed the very great extension of chemical knowledge in the direction of the constitution of the molecules of carbon compounds. Stereochemistry touches plant life most obviously in its relation to the carbohydrates, which are constructed by the green plants, and digested and utilized by all. The phenomenal work of Fischer on the sugars, supplemented as it has been by that of Tollens, Kiliani, Lobry de Bruyn and others on asymmetric carbon atoms, has put us in possession of facts which throw a flood of light upon nutrition and are destined when more completely exploited and fully applied, to elucidate many difficulties in our present thinking about the feeding of plants.

We have learned for example that a carbon compound, to be a valuable food, must not only contain C, H and O, but that these must be combined in a particular fashion. The aldehyde group CHO, the ketone group CO, and the radical $CH_2OH$ are characteristic of good foods. The simpler sugars such as glycerose and arabinose; the hexoses, glucose or grape sugar, fructose, or fruit sugar, mannose and galactose; the polysaccharides, sucrose or cane sugar, lactose or milk sugar, and maltose or malt sugar are all substances which have been proved useful as plant foods, and all contain one or more of these groups.

Up to a certain limit, the presence of a particular molecular group increases the food value. What does this phrase 'food value' mean? Does food value depend solely on availability of energy, *i. e.*, the ease with which it can be released? Or has the form in which energy is set free something to do with its availability and the consequent food value? Or does the constitution of the molecules before and after decomposition affect food value? If so, is it because the constitution of the molecules is related to the form in which energy is released or because it is related to the ease with which energy is released?

When the complex carbohydrates like starch and inulin are to be utilized, they break down through a series of dextrins and levulins respectively, finally becoming simplified to hexose sugars. Why is this necessary? And how are we to interpret these decompositions? Are they part of the energy-release? It can hardly be doubted that the constitution of the molecules of starch and inulin, composed as they are of units of glucose and fructose, determines the permanence while in the storage form, and that separation into their constituent units in digestion makes possible the assimilation of the sugars as food. It is plain, therefore, that a precise knowledge of the constitution of starch and inulin is a desideratum. We must look forward also to further extension of stereochemical knowledge of the almost infinite variety of

the other carbon compounds and to the investigation of the nitrogenous substances, as yet scarcely well begun. These may be expected to put physiologists into possession of valuable clues to the secrets of nutrition and respiration.

How intimate this relation between the arrangement of atoms in space and physiological activity is, is to be seen in the fact that fermentability is dependent upon the configuration of the sugar molecule. It has been found that, of the many sugars known, only those with 3, 6, or 9 atoms of carbon in the molecules are fermentable. Thus the triose sugar, glycerose, whose formula is $C_3H_6O_3$, is fermentable, while the tetrose sugar, erythrose, $C_4H_8O_4$, and the pentoses, ribose, lyxose, xylose, and arabinose, $C_5H_{10}O_5$, are not. In like manner several of the hexoses, $C_6H_{12}O_6$, and the nonnoses, $C_9H_{18}O_9$, are fermentable, while the intermediate ones, such as the heptoses, $C_7H_{14}O_7$, are not.

But the relation is yet more intimate. Even when the proper number of atoms is present they may be arranged in such a fashion as not to be open to disturbance by an organism.

Thus, certain species of yeast are capable of fermenting *d*-glucose, *d*-mannose, and *d*-galactose. The arrangement of their molecules may be represented in a plane as follows:

$$\begin{array}{rl} & \quad\quad\quad\ \ \mathrm{H\ \ H\ \ OH\ \ H} \\ d\text{-glucose} = & \mathrm{CH_2OH—C—C—C—C—COH} \\ & \quad\quad\quad\ \ \mathrm{OH\ OH\ H\ OH} \end{array}$$

$$\begin{array}{rl} & \quad\quad\quad\ \ \mathrm{H\ \ H\ \ OH\ OH} \\ d\text{-mannose} = & \mathrm{CH_2OH—C—C—C—C—COH} \\ & \quad\quad\quad\ \ \mathrm{OH\ OH\ \ H\ \ H} \end{array}$$

$$\begin{array}{rl} & \quad\quad\quad\ \ \mathrm{H\ OH\ OH\ H} \\ d\text{-galactose} = & \mathrm{CH_2OH—C—C—C—C—COH} \\ & \quad\quad\quad\ \ \mathrm{OH\ \ H\ \ H\ OH} \end{array}$$

But *d*-talose, whose structure is the following:

$$\begin{array}{l} \quad\quad\quad\ \ \mathrm{H\ OH\ OH\ OH} \\ \mathrm{CH_2OH—C—C—C—C—COH} \\ \quad\quad\quad\ \ \mathrm{OH\ \ H\ \ H\ \ H} \end{array}$$

cannot be fermented by these yeasts. Inspection shows that *d*-talose differs from *d*-galactose and *d*-mannose only in the transposition of the molecular groups about a single one of the asymmetric carbon atoms, and from *d*-glucose only in the transposition about two carbon atoms.

Again, while *d*-glucose,

$$\begin{array}{l} \quad\quad\quad\ \ \mathrm{H\ \ H\ \ OH\ H} \\ \mathrm{CH_2OH—C—C—C—C—COH,} \\ \quad\quad\quad\ \ \mathrm{OH\ OH\ H\ OH} \end{array}$$

is fermentable, its isomer, *l*-galactose

$$\begin{array}{l} \quad\quad\quad\ \ \mathrm{OH\ OH\ H\ OH} \\ \mathrm{CH_2OH—C—C—C—C—COH,} \\ \quad\quad\quad\ \ \mathrm{H\ \ H\ \ OH\ H} \end{array}$$

is not at all fermentable.

The discovery that yeasts, long believed to show direct ferment action of the protoplasm, produce the chemical changes known as fermentation by the intervention of enzymes, removes the problem from the immediate field of physiology, only to group it with the host of baffling catalytic phenomena which the chemist is at present wholly unable to explain. Thus all fermentations at present known become closely associated with the digestive processes in nutrition. We may scarcely expect light upon all these phenomena until the preparation of the enzymes in a state of purity is attained. This, it is to be hoped, will be followed by a knowledge of their composition, though, as they now appear to belong to the group of nucleo-proteids, this may only be ascertained when the long-awaited desideratum is attained and we know the composition of proteids themselves.

The action of the enzymes, which is limited by the molecular constitution of the substances they hydrolyze and break up, is

probably dependent upon their own constitution. Fischer's researches seem to show that the molecular relation between the two are as intimate as those between a key and the lock whose wards it must fit before the position of the parts can be altered. If this proves to be true, we shall look for a better understanding of the processes of digestion with the further extension of the stereochemistry of the nitrogen compounds.

Again a knowledge of the physiological action of definite radicles, which may differ according to their position in the molecule, is being reached by determining the effect of the introduction of a certain radicle or of a change in its position. The ability to alter chemical structure at will by known reactions puts it into our power to ascertain how each change affects the protoplasm. Thus in the phenols, a series of compounds allied to the tertiary alcohols, of which the so-called 'carbolic acid' is a familiar example, True and Hunkel find that the introduction of the nitro group ($NO_2$) or the methyl group ($CH_3$) into the benzene nucleus increases the poisonous effect, while an increase in the number of hydroxyl groups (OH) or nitro groups ($NO_2$) has little or no effect.

### PHYSIOLOGICAL MORPHOLOGY.

Within the past decade attention has been especially directed to the causes which affect the development of plants and determine both form and structure. A moment's thought suffices to impress upon any one the fact that a great number and extreme variety of external agents are acting and interacting in most complex fashion upon all plants. Some of the more obvious of these groups of external causes are even popularly recognized. Thus one hears it said that poor soil and scanty water is the cause of the dwarfing of plants, which under better conditions attain a greater stature.

Such apparently obvious deductions may be correct, or may not be, but satisfactory and accurate analysis of the effects of external agents is a problem of the utmost difficulty, because it is well-nigh impossible to alter experimentally one condition without really altering others at the same time. The solution of the problems of physiological morphology is, therefore, only to be attained by the most assiduous care in experiment and induction.

*Morphology.*—In illustration of these problems I may refer to the recent studies made by Klebs on the external factors which control various reproductive processes among the algæ. By experimental analysis he has sought to determine the bearing of light, temperature, density of medium, and various other agents upon the production of zoospores and gametes. These studies have shown that it is possible to call forth a definite and very complicated physiological process, of far-reaching consequences, by appropriate changes in the environment. How they operate remains yet to be explained.

In the higher plants the investigations of Goebel and many others have shown the possibility of controlling growth and development in a similar way and to a remarkable extent. The relation between the different members of a plant has also been exploited, largely within the past decade, although its beginnings were long ago. The study of correlations has cast much light upon the causes of form, and has made more impressive than ever the wonderful plasticity of plants.

*Correlations.* — Qualitative correlations, particularly, offer an inviting though difficult field for investigation. I need only mention a few examples of such correlations. Upon the removal of the terminal shoot of a pine, one or more of the lateral shoots erect themselves and undergo appropriate changes in mode of internal growth

and development, acquiring radial structure instead of dorsiventral, and branching on all sides instead of on the flanks. The transformation of sporophylls to foliage leaves following the removal of normal foliage has been a long-known example, to which renewed attention has been directed by the fine illustration of such change obtained in the experiments of Professor G F. Atkinson. It was shown by Knight nearly a century ago that the subterranean shoots of the potato, upon removal of the aerial parts, rise above ground and develop ordinary foliage leaves and flowers instead of tubers; while, conversely, the enclosing of aerial shoots in a dark chamber with saturated air gave occasion for the development of tubers, a phenomenon which is not uncommon under other than experimental conditions. A large number of similar transformations are now known.

Besides the accumulation of a greater range of such phenomena, we must look to the future for a luminous theory of this reciprocal influence of organs. At present there is little that is satisfactory in the discussion of the nature of correlation. In what conceivable way can the removal of one member act upon other parts so as to alter the course of its normal development? What can be the nature of the stimulus which overcomes the diageotropism of the horizontal subterranean branches of the potato, and induces upright growth and the development of foliage?

Regarding the quantitative correlations we are quite as much in the dark; perhaps more so, because of the relation of other functions. It is now clear that the greatly enlarged leaves and stems which develop after decapitation of a tree are in some way due to the increased food supply. But in what relation does the supply of food stand to these growths? Is the extensive removal of parts alone the stimulus which determines the revival of dormant buds and the formation of adventitious buds? Or does the increased amount of food act as the stimulus? But our present view of the movements of foods is that it is due to removal from solution, at the point where they are being used, of the substances which are needed. The using of food, indeed, is looked upon as both actuating and regulating, in large measure, the movement of food to any point. How, then, consonant with these ideas, can a superfluity of food occur at any point, there to act as a stimulus? Or how can excess of food in any way determine the increased *use* of food and so accelerate the growth of parts?

*Pathology.*—Closely connected with the study of the normal activities of plants are disturbances in the rate and character of function which are properly included under the term pathology. During the past decade very rapid advance has been made in a study of those pathological changes which are due to the presence of a foreign organism. Indeed, the phrase 'diseases of plants' calls to mind almost exclusively the effects of parasites, which cause wilting by mechanical stoppage of water supply, extraordinary growths in the form of tumors, destruction of chlorophyll to the detriment of photosynthesis, and a host of other evident changes. Indeed, as compared with other fields, we are tempted to say that this has been over-cultivated. The difficulty, however, is not so much in over-investigation as in over-publication regarding the distribution of the diseases and the application of palliatives and remedies. This is, in a measure, justified by the enormous economic value of the crops attacked. But one cannot help wishing that the staffs of our experiment stations particularly would give greater attention to investigations on the nature of diseased conditions than to repeating again and again the study of remedial operations.

There is thus one phase of pathology which has yet been comparatively neglected. The presence of a definite organism, whose activities clash with those of the host to the injury or death of the latter, is in itself an incitement to investigation. But we need also knowledge of those disturbed functions whose causes are dependent on other stimuli than the presence of a parasite. Some of these are doubtless internal and may long remain obscure, even as the causes of the so-called 'spontaneous' movements have hitherto eluded observation. But unquestionably many plant diseases are due to untoward conditions of the environment, working sometimes through chemical, sometimes through mechanical, sometimes through ethereal stimuli. This sort of work has been vigorously undertaken by the Division of Vegetable Physiology and Pathology at Washington, with full consciousness of the fact that, in order to attain results of value, there must be a fuller and more accurate knowledge of the normal processes.

At this point we are confronted by the difficulty of determining what processes are normal and what are pathological. It is the old question of sanity and insanity in a new guise—a question which each is tempted to answer in the same way as the old Quaker, who remarked to his wife: "Wife, they're all daft but thee and me; yea, and sometimes I think *thee* seems a little queer." What action shall be chosen as a norm is a matter of judgment, the general vigor of the plant alone serving as an imperfect criterion; imperfect, because we do not always know what constitutes vigor. Thus the study of pathology needs not only the examination of parasitic diseases, but also a wide acquaintance with the proper activities of healthy plants in order to determine what derangements are produced in them by untoward circumstances and obscurer internal causes. In the latter is an almost unworked field which promises rich reward for patient investigation, and that not only for the sake of pure science, but also for applied physiology as well.

If parasitic diseases cause among cultivated plants a loss of millions annually, is it unlikely that factors which can be controlled, if it is worth while to do it, cause in our crops a shortage whose money value may be many fold greater? There are already practical experiments tending to show that most of our field and garden crops steadily suffer for want of water, a want which windmills and water-driven electric pumps might often supply to great profit. We may not guess; we must *know* by experiments on a large scale whether or not it will pay to supply water and to control other unfavorable conditions, before we dare recommend such measures to a practical world.

IRRITABILITY.

I must now turn to a topic which is really deeply involved in all that I have already discussed, but one that deserves special mention. I mean the relation of irritability to the well being of plants. Seventeen years ago Sachs wrote: "Irritability is universal in the vegetable kingdom . . . Vegetable life without irritability is just as inconceivable as animal life without irritability. Irritability is the great distinguishing characteristic of living organisms; the dead organism is dead simply because it has lost its irritability."

It would be impossible to state the case more strongly. But it is one thing for him who has conceived a truth to state it clearly, and quite another thing to have this truth enter into the thinking and the experimenting of investigators. Long after the clear annunciation of the importance of irritability by the great physiologist—the father of modern plant physiology—too many were finding the chief rôle of irritability in those reactions which by deform-

ing the body moved the connected parts. Plant movements, especially those due to changes of turgor, were long looked upon as the main evidence of irritability in plants. This conception was reflected in the text-books of the older day and still survives in many of the more elementary works.

After the bearing of irritability on movements was firmly established, it came to be seen that the regulation of the rate of growth and its resumption by certain parts which had ceased to grow was accomplished through irritability. Growth, therefore, as well as movement, had important relations to irritability. But during the past decade, particularly, a better conception has been taking possession of physiological students. It is now perceived that *all* protoplasmic functions are initiated or controlled by external physical or chemical agents. This point of view is reflected in that masterly treatise of Pfeffer, the second edition of his *Pflanzen-physiologie.* Throughout the first volume, discussing the physical and chemical phenomena connected with metabolism, the ability of the protoplasm to regulate its own operations and to control even the physical changes in adjacent parts is everywhere presented and insisted upon.

The idea of a stimulus, instead of being confined, as it once was, to the action of heat, gravity and moisture, has now been greatly extended. Any external or internal change, slight or profound, gradual or sudden, which calls forth a corresponding change in the living protoplasm, is to be looked upon as a stimulus. The responses to stimuli, too, once thought of largely as those visible in curvature of motor organs or growing parts, are now conceived as of great variety. Invisible reactions probably outnumber the observable ones. Those producing a change of bodily form must be relatively few as compared with those which influence the performance of function or the course of development.

Diverse and numerous as are the stimuli which act upon plants, any conception of their operation would be faulty which fails to take into account the fact that stimuli of many unlike kinds and of unequal intensity are *interacting* to bring about the peculiar form and behavior of each individual plant. Think of the external agents which are known to be acting upon an ordinary land plant. About the aerial part the temperature varies from season to season, in our temperate zone changing from 30° below C. zero to 50° above; it varies from month to month and from day to day, even from hour to hour. The light differs in intensity and direction from day to night and from hour to hour. It changes in its actinic effect, as the photographer well knows, in the course of a few minutes; a variation, by the way, whose effect on plants has been entirely unstudied as yet. The moisture in the air is hardly the same for any two consecutive days; the plant is deluged with water for some hours or days and dry between rains; it is enveloped in fogs and mists; wet with dews at night, and all but blistered by the sun during the day. Its subterranean part is surrounded by solutions whose amounts and composition are probably varying hourly; whose concentration and consequent dissociation is changing from time to time. The temperature of the soil is scarcely the same from hour to hour; it varies between day and night, from day to day and from season to season. Imagine now the numberless combinations possible among these varying factors, and remember that all these interact as stimuli upon the protoplasm. What wonder, then, that no two plants are alike; that Capsella may flower at 5 cm. height with a few minute entire leaves, or may grow ten times higher with abundant foliage and long racemes of fruitful flowers!

This different conception of irritability and its relations to the functions of the

plant has led to many fruitful investigations during the past decade. The ingenious applications of plaster jackets for mechanical restraint of growth has thrown light not only upon the mechanical forces which can be exerted by growing organs, but casts a side light upon the difficult problem of the mechanics of growth. Researches upon the mechanics of curvature induced in growing organs by stimuli have been made by several observers, without obtaining, however, the concordant results which are to be desired. The subject, therefore, requires further study.

A satisfactory hypothesis as to what happens when an irritable organ is stimulated is still a desideratum. Is irritable protoplasm merely in a state of extraordinary lability, and does the stimulus initiate the decomposition of the protoplasm or of some unstable substance which it has produced? If this is true the metabolism of irritable organs which have been strongly stimulated ought to be different from that of similar but quiescent organs, and different products may be expected. One of the most noteworthy advances in this direction seems to be the discovery by Czapek (unfortunately we have had as yet only a preliminary paper) that roots after being geotropically stimulated contain notable amounts of reducing substances as compared with unstimulated roots which contain oxidizing substances instead.

Again, the transmission of impulses in plant tissues has been under frequent study. Haberlandt's seemingly well-founded conclusions regarding the transmission of impulses in Mimosa have proved untenable in the light of MacDougal's experiments, which also seem to shut out the possibility of the action of living protoplasm. The travelling of an impulse through a zone of dead cells is so marvellous that we are tempted to discredit the evidence of our senses, but that it occurs cannot be doubted. Thus, again, the discordant results of competent observers compel us to say that as good as nothing is now known.

ECOLOGY.

Within the past decade what may be considered a new division of plant physiology has been organized and has entered upon a development whose future extent and importance cannot yet be fully estimated.

Like every apparently new departure, it is an evolution from the old. Though its rise has been phenomenal, many of its facts and principles have long been known. At the meeting of the Madison Botanical Congress of 1893 the word *ecology* was almost new to American ears, and doubtless some present at that Congress were surprised at the introduction of a resolution on so unimportant a subject. The adoption of a name and preferable form of spelling for the new science, however, has been very useful in unifying the practice of American writers, and is a good illustration of the beneficial effect of a formal agreement on a matter of usage.

In the last century the relations of plants to insects were studied and Christian Conrad Sprengel's *Entdeckte Geheimniss der Natur* was a pioneer work in this subject. But Sprengel's work was destined to be forgotten for many years, and the further study of these interesting adaptations for the pollination of plants by insects was only revived by the prolonged observations and ingenious experiments of Charles Darwin. Since his time the work has been taken up vigorously and knowledge enormously extended by Müller, Ludwig, Delpino, McLeod, Robertson and a host of others.

The controlling influence of soil and climate upon the distribution of plants was also recognized and measurably understood long ago. In the classical works upon geographical distribution, such as Grise-

bach's *Vegetation der Erde* and Drude's *Pflanzengeographie*, the main features which form the basis for the grouping of plants are found to be those which constitute climate. Thus the moisture and heat relations of plants have dominated our thinking. The importance of these factors has particularly impressed itself upon students of local distribution. Again and again, in the past half century, local lists of plants have been compiled with little reference to the other conditions which determine the growth of plants. The limits of these local floras have been political boundaries, rather than the natural barriers to plant migration, or the physical features which determine climate. It has been the edge of the county, the boundary of the State, the limits of the country, which have been chiefly considered. In later years, however, the recognition of natural boundaries has become more common in these lists, and more attempts have been made to study the flora of a certain valley, a river system or a table land. Even so, however, natural barriers have been looked upon as controlling plant distribution merely through their effect upon climate, to the neglect of other factors.

In the last decade the increasing attention which has been given to the effect of external agents of all kinds upon plants, and the growing appreciation of the effect of stimuli upon plant form, acting through universal irritability, has led to the consideration of all the causes, small as well as great, which influence the well-being of plants. This knowledge, gradually accumulated, was first organized by Warming in his epoch-making work upon plant associations. Thus the subject of *ecology* was launched. The appearance of this great work not only brought into connection facts concerning the relations of plants to one another; it cast a new light upon the subject of plant geography. Facts and statistics which before had been dull and uninteresting to many, because without philosophy, now became luminous with new meaning.

This new light upon the geography of plants comes not merely from a consideration of the effect of the great factors of light, heat, moisture, and soil structure upon the plant; for these had been in a measure appreciated before. The new meaning arises from the introduction into the problem of the many minor factors of environment which act as stimuli and of the interminable variety of combinations which these present in their influence upon plant welfare. Among these environing conditions none is of greater importance than the effect of one plant upon another, partly direct and partly indirect, befriending some neighbors and injuring others. Because of these relations there arise groups of plants which grow well together, and others which are so antagonistic that they fly from one another's presence. These groundings may be due to causes the most remote or to relations the most intimate; according as they are due to one or the other will the association be closer or distant, the group large or small.

This phase of ecology, the study of plant societies, is yet in a somewhat chaotic condition. Not all the materials which are at hand have been satisfactorily organized, and much remains for future research. We await with impatience the settlement of various questions as to interpretation, and the acquisition of the multitude of new facts which are necessary before any true picture of the causes of form and the distribution of plant life is attainable.

It is a matter of some national pride that ecological investigations have been taken up vigorously by students in our own country, and that from the new standpoint some valuable researches on plant distribution have already been made. It is per-

haps also a matter of local pride that the most extensive study has been made in one of our great Western States, whose flora has been as yet comparatively little altered by the most potent of all disturbing factors, the hand of man. The *Phytogeography of Nebraska*, published a year or two ago by Pound and Clements, is the first extended study on plant geography in this country along distinctively ecological lines. The care and completeness with which their investigation was made render it a good example for future students of our flora, yet one which doubtless succeeding contributions will improve upon as the subject becomes better organized. As other examples of similar study may be mentioned the paper of Professor MacMillan upon the more restricted flora of the Lake of the Woods, and the only partially published work of Dr. Cowles upon the flora of the Lake Michigan dunes.

*Plant names.*—I venture to say that one of the most significant results of the study of ecology and physiological morphology is the growing dissatisfaction which its students feel with present methods of nomenclature, or perhaps I ought to say classification. I do not refer to the large grouping of plants into families, orders and divisions, but to the grouping of individual plants into species. This dissatisfaction is finding its expression among taxonomists as well. On the establishment of new species we are hearing almost daily the plea that it is better to separate into many species a group of nearly allied forms, although the differences used to distinguish them be very much slighter than those heretofore used for species. That is, it is better to do violence to our old idea of a species than to group together forms that in the field are easily recognized as unlike. This simply means that collectors and systematists are recognizing more fully the differences produced by unlike environment. It is a matter of common remark that the differences between individual plants recognized as belonging to one species are often greater than those which are used to separate species. Domesticated plants so easily pass into a variety of forms that for the sake of maintaining a rigid idea of specific rank cultivated plants have been quietly ignored. Now we are coming to see that in nature as in cultivation the plant is so plastic an organism that it is almost impossible to group together any individuals except those growing under identical conditions. What was devised as a convenience—namely, the establishment and naming of a species—is coming to be more and more of doubtful utility.

I will not undertake to say how much this species idea and nomenclature has retarded the true view of plant plasticity, but I feel sure that a good case might be made out for such a thesis. Whether any scheme can be devised which can replace the binomial nomenclature, whether any better method can be used by naturalists for designating the organisms which they are studying, is a matter for the future. I venture to prophesy, however, that the present system of nomenclature, by which I do not mean any particular kind of practice, whether of Paris, or Berlin, or Kew, or Cambridge, or Rochester, but the fundamental method of naming plants itself, *must go*. Our mere judgments, which we call species, foisted upon plants, do not conduce to a clear understanding of vegetable phenomena, but rather blind our eyes to a recognition of otherwise obvious truths. Some other method of identifying plants must be devised.

## CYTOLOGY.

There is yet one other field whose development I must not fail to mention, though it does not pertain wholly to plant physiology. It goes without saying that the

functions of the plant body resolve themselves into the functions of the unit of that body. In every organ, however simple or however complex, we recognize the individual protoplast as the unit of work as well as the unit of structure. Each, enclosed in the armor-like wall which it has formed for itself, though hampered in its movements, is able to carry on the chemical and physical processes which constitute life without notable hindrance. Within the protoplast, for which Sachs uses the expressive though unnecessary word energid, there go on certain changes that can be observed with the microscope. These changes we look upon as the index of the invisible ones whose significance we seek to understand. It is natural, therefore, that the closest scrutiny should be made of the observable changes which take place within the cell. This minute study began in the attempt to ascertain how the living protoplasm constructed the wall with which it jackets itself. Every difference in composition which involved an optical alteration in the transmission of light, and so became visible, has been studied with the utmost care.

Later, attention was attracted to the division of the various independent protoplasmic organs within the cell body. Some of these have been found to be relatively simple. The division of the nucleus, however, has shown a complexity and at the same time a regularity which has challenged the minutest investigation and has made it the center of the greatest interest. So complex a series of changes, recurring with such regularity, argues an importance for both function and phylogeny which has made students eager to discover the secret. Therefore, within the last few years the behavior of the nucleus and of its different parts has been under study in all groups of plants with an exactitude never before dreamed of. Thus cytology has come to be an almost independent line of investigation. It is to be feared, however, that in many cases its exaltation has led students to mistake its real purpose and to consider it an end in itself. The visible processes within the cell will have little meaning unless they are looked upon as the mere index of its work. Unless the details of mitosis, for instance, are interpreted in the light of function or phylogeny they will certainly be misinterpreted or will be meaningless. It is becoming a question whether we have not overestimated the importance of slight differences in nuclear phenomena and whether further knowledge can be expected from a study of the visible processes within it. At the same time decided progress is to be hoped for in a more intimate chemical knowledge of the substances composing the nucleus, as to their chemical constitution and their relation to chemical reagents, such as stains and fixing fluids, rather than in repeated counting of chromosomes and multiplied observation of the details of prophase and anaphase.

I have now discussed the chief features of plant physiology in which notable progress has been making during the last decade. The great advances in plant chemics and physics; the progress in the investigation of causes of plant form; the widening ideas of the property of irritability; the investigation of the social relations of plants, and the minute study of cell action in spite of their diversity, have one great end in view. This is nothing less than the solution of the great problem—the fundamental problem—of plant physiology, as of animal physiology. The secret which we must discover, the dark recess toward which we must focus all the light that can be obtained from every source, is *the constitution of living matter*. Entrenched within the apparently impregnable fortress of molecular structure this secret

lies hid. The attacks upon it from the direction of physical chemistry and physiological morphology, of irritability, of ecology, and of cytology, are the concentrating attacks of various divisions of an army upon a citadel, some of whose outer defences have already been captured. The innumerable observations are devised along parallel lines of approach, and each division of the army is creeping closer and closer to the inner defences, which yet resist all attacks and hide the long-sought truth. We see yet no breach in the citadel. Here and there we seem to approach more closely and at certain points are getting glimpses, through this loophole or that, of inner truths, hidden before.

One outer circle of defences yet remains untaken, and until that falls it would seem that there is little hope of capturing the inner citadel. We *must* know more of the constitution of dead substances chemically related to the living ones. When the students of chemistry can put the physiologists into possession of the facts regarding dead proteids we shall renew the attacks more directly, with greater vigor and greater hope of success.

That ultimate success is to crown our efforts there is little reason to doubt. Ten years ago we little dreamed of the tremendous strides as since made toward the interpreting of life's central truth. The success of the past is the best augury for the future. The brilliant researches upon the chemistry of carbon compounds inspire us with renewed hope and put into our hands almost daily new weapons.

It is not possible to prove to-day that life and death are only a difference in the chemical and physical behavior of certain compounds. It is safe to say that the future is likely to justify such an assertion. In the meanwhile we press forward along the whole line. Botany is more than ever full of meaning, because with its sister sciences it is no longer seeking things, but the reasons for things. CHARLES R. BARNES.

UNIVERSITY OF CHICAGO.

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## *SECTION A—ASTRONOMY AND MATHEMATICS.*

THE address of Vice-President Alexander Macfarlane entitled 'The Fundamental Principles of Algebra,' and the 'Report on Progress in Non-Euclidean Geometry,' by Professor George Bruce Halsted, of the University of Texas, are both to be published in full in SCIENCE and will not be treated further here.

*A Report on the Recent Progress in the Theory of Linear Groups*, presented by Professor L. E. Dickson, of the University of California, was of the nature of a supplement to the report on finite groups, read at the last annual meeting of the Association, by Dr. G. A. Miller, of Cornell. It is intended for publication in the *Bulletin of the American Mathematical Society*, in which the report of Dr. Miller appeared last year.

Part I. of the present report gives the general theorems relating to the canonical form of finite groups of linear substitution and to the generators of such groups. After a complete enumeration of the binary and ternary collineations in their historical setting, a number of special quaternary linear groups, particularly the famous one of order 51,840, are considered.

Part II. treats of linear groups in a Galois field, their order, generators, factors of composition and the isomorphisms existing between them. The Galois field is defined and a full bibliography added. The general linear homogeneous group, the linear fractional group, the Abelian linear group and its generalized form, the first and second hypoabelian groups, the orthogonal group, other linear groups with a quadratic invariant or a special invariant of degree $q$, the hyperorthogonal group and the hyperabelian group are all treated in turn. A number of

isomorphisms existing between these groups are tabulated. As many as six forms of a single group of order 25,920 are given, this group having applications in various geometric problems.

Professor Asaph Hall, Jr., of the University of Michigan, communicated to the Section certain results of a series of observations of the meridianal zenith of Polaris made by him between May, 1898, and July, 1899, with a view to determining the latitude variation at Ann Arbor and the aberration constant. The observations were made above and below the pole, both direct and reflected. The direct observations, at upper and lower culmination, respectively, give the values for the aberration constant 20″.60 and 20″.58, and for the parallax 0″.32 and 0″.29. The reflected observations show a close agreement with the direct observations. The observations are being continued.

A paper entitled 'Ancient Eclipses and Chronology' was presented by R. W. MacFarland, of Oxford, O. It is, in the main, a critical examination of the sources in ancient history from which the commonly accepted dates of various events are determined, and especially such sources as involve references to eclipses. The author of the paper reaches the conclusion that in each case examined the historical statement connecting a specified important event with an eclipse is either inadequate to establish accurately the relation of the two in time or else that the computations of the astronomers of the present day are not of sufficient accuracy to fix the eclipse in question within several years of the truth.

Professor H. C. Lord, of the Ohio State University, gave an interesting account of an investigation in which he has lately been engaged as to the best relative dimensions for different parts of a spectroscope which is to be used photographically, not visually. His account was fully illustrated by photographs and tables of results. He insisted especially upon certain advantages to be gained by using a camera of considerable focal length rather than one of short focus.

The proof of Grassmann's fundamental theorem, that there can be but two kinds of lineal multiplication of two factors, is somewhat long and rather difficult to follow. The object of the paper presented by Mr. Jos. V. Collins was to show how this proof may be shortened and simplified.

Professor G. J. Stokes, of Queen's College, Cork, Ireland, was prevented by sickness from finishing his paper on 'The Theory of Mathematical Inference.' The abstract of the incomplete paper indicates that the theory is advocated that the fundamental truths of mathematics are logical consequences of the mere fact or possibility of synthesis generally, and that ordinary mathematical inference is compounded of a logical or analytical element which has been reduced to mathematical form in Boole's Laws of Thought, and a synthetic element represented by Algebras of the type of Grassmann's *Ausdehnungslehre*.

A paper entitled 'Practical Astronomy during the First Half of the Present Century,' by Professor T. H. Safford, of Williamstown, Mass., unfortunately arrived too late to be read before the Section. It is a short and interesting account of the relations of the eminent astronomers Gauss, Bessel, the elder Struve and Airy to the astronomical progress made during the period stated.

Dr. G. A. Miller, of Cornell University, presented a short and interesting paper 'On the Commutators of a Group.' The following relations were brought out and commented upon by Dr. Miller: (1) If with a given group (G) commutators are formed with a fixed operator and all the operators of that group these commutators will generate a group which is transformed into itself by all the operators of the group G. (2) When the fixed operator transforms the

group G into itself the given commutators generate the smallest self-conjugate subgroup of G, which has the property that all the operators of the corresponding quotient group are commutative to the fixed operator. (3) If one of the elements of a commutator be multiplied on the left by each of the operators of a group it will be observed that the commutator remains unchanged when the multiplier is commutative to the other element, and that it is changed for every other multiplier. Hence this commutator has as many different values as the fixed element has conjugates when it is transformed by all the operators of the given group.

S. Kimura, of Japan, furnished a paper on 'Linear Vector Functions.'

One of the most interesting papers upon the program of Section A was 'The Determination of the Nature of Electricity and Magnetism,' by Professor R. A. Fessenden, of Western University, Allegheny, Pa. It was read before a joint session of Sections A and B, and will be reviewed in connection with the papers of Section B.

The fact that the American Mathematical Society was to hold a separate meeting at Columbus on Friday and Saturday of the Association week, and that the Conference of Astronomers and Astrophysicists is to be held at the Yerkes Observatory early in September, a date just late enough to make it inconvenient for persons who attended the Columbus meeting, both tended to reduce the length of program and the numnumber in attendance at Section A. It is to be hoped that the organizations in question may in the future see fit to cooperate with Section A. It seems obvious that many benefits must accrue to each of the three organizations from such cooperation, for they have many common members and common interests.

JOHN F. HAYFORD,
*Secretary of Section A.*

## *ELEVENTH ANNUAL MEETING OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS, COLUMBUS, OHIO, AUGUST 18 AND 19, 1899.*

THE Association met in room 4, Biological Hall, Ohio State University, at 10 a. m., August 18. Fourteen members and a number of distinguished visitors were present, the average attendance at the four sessions being about twenty. The address of the retiring President, Mr. C. L. Marlatt, Washington, D. C., on 'The Laissez-faire Philosophy applied to the Insect Problem' was treated with an originality as courageous as refreshing. The author depicted the harmonious action of nature and called attention to her abundant powers of recuperation and self protection. The fundamental principles underlying the excessive multiplication and injury characterizing new or introduced species were explained, and an attempt was made to show the futility of efforts to prevent the introduction or secure the extermination of foreign insects once established in this country. These introductions of new forms are world movements not to be thwarted by man. The exploiting of short-lived or easily controllable ills was condemned and the unfair restrictions placed upon commerce by such efforts were pointed out. From the author's standpoint the only legitimate field for efforts in applied entomology is that of the local control of injurious species, and here the entomologist finds ample opportunity for the exercise of his powers in behalf of mankind. A general discussion of the address followed and while some of the members present were unable to accept entirely the conclusions of the author, all agreed that the address constituted a very important and valuable contribution to the philosophical literature of applied entomology.

Active members were elected as follows: C. S. Banks, Albany, N. Y.; Arthur Gibson, Ottawa, Canada; H. P. Gould, Col-

lege Park, Md.; S. J. Hunter, Lawrence, Kan. The foreign members elected were: Edward Barlow, Calcutta, India; E. E. Green, Pundaluoya, Ceylon; A. M. Lea, Hobart, Tasmania; J. S. O. Tepper, Adelaide, South Australia.

The list of papers read and discussed included the following: 'A Destructive Tanbark Beetle,' A. F. Burgess (read by the secretary); 'Voluntary Entomologic Service in New York State,' 'Notes of the Year for New York,' E. P. Felt; 'Recent Work against the Gypsy Moth,' 'The Destruction of Hairy Caterpillars by Birds,' E. H. Forbush; 'A Remedy for Gad-flies; Porchinski's Recent Discovery in Russia, with some American Observations,' 'The Establishment of *Blastophaga psenes* in California,' L. O. Howard; 'The Pea Louse, A New and Important Species of the Genus *Nectarophora*,' 'A New Method of Handling Hydrocyanic Acid Gas in Orchards,' 'Entomological Notes from Maryland,' 'The Stalk Worm, a New Enemy to Young Tobacco,' W. G. Johnson; 'An Improvement in the Manufacture of Arsenate of Lead,' 'A Probable Remedy for the Cranberry Fire-worm,' A. H. Kirkland; 'Miscellaneous Notes,' C. L. Marlatt; 'The Original Home of the San José Scale,' C. L. Marlatt and L. O. Howard; 'Observations on Insects of Sandusky and Vicinity,' H. Osborn; 'Insects of the Year in Georgia,' A. L. Quaintance; 'The Fatal Temperature for some Scale Insects in Georgia,' W. M. Scott; 'Insectary and Office Methods,' 'An Interesting Outbreak of the Chinchbug in Northern Ohio,' F. M. Webster; 'Insects of the Year in Ohio,' F. M. Webster and C. W. Mally. The following papers were read by title: 'A New Breeding Cage for *Schizoneura lanigera*,' W. B. Alwood; 'A Destructive Orange Borer imported from Japan,' 'The Full Life History of *Pulvinaria acericola*, W. and R.,' L. O. Howard.

Officers for the ensuing year were elected as follows: President, Lawrence Bruner; First Vice-President, C. P. Gillette; Second Vice-President, E. H. Forbush; Secretary-Treasurer, A. H. Kirkland.

Resolutions were passed: (1) endorsing the work of the Massachusetts Gypsy Moth Committee; (2) the quarantine work of the California State Board of Horticulture; (3) expressing full sympathy with judicious State and National legislation tending to prevent the introduction of foreign insect pests and to secure the control or extermination of such as have become established in this country; (4) expressing appreciation of the action of the Honorable Secretary of Agriculture in publishing the proceedings of the Association in previous years; (5) expressing thanks to the local committee and the officers of the Association. The next meeting will be held on the two days preceding and at the same place as that of the American Association for the Advancement of Science.

A. H. Kirkland,
*Secretary.*

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## *SCIENTIFIC BOOKS.*

*I Sogni, Studi psicologici e clinici di un alienista.* Sante De Sanctis. Turin. 1899.

This latest of books about dreams and dreamers is written not only, as its title indicates, from the standpoint of the alienist, but also from that of the comparative psychologist. Its introductory chapters on literature and method are followed by discussions of the dreams of animals, children, old people and adults, of the dreams of the neuropathic, the mentally deranged and the delinquent.

It is safe to say that no book ever written on the subject has taken into account so large a number of dream experiences, for De Sanctis throughout compares the results of his own observation with the published records of the study of others. The book has thus a bibliography of three hundred and twenty-three numbers, though it dispenses with the convenience of page references.

The method of investigation which is most often employed is that of the statistical inquiry, but this is supplemented by the methods of personal questioning, observation of the sleeper's movements and experimental stimulation.

Practically all the methods by which dreams have been studied are therefore employed, except that of 'direct observation,' by which the dreamer, immediately after waking, records his own dreams and notes their vividness, their relation to waking experience and other important features. De Sanctis justly criticises this method, on the ground that the intention of studying one's dreams is itself an artificial condition, predisposing the subject to dreams of unusual frequency and of unnatural content; but the difficulty, which undoubtedly exists, he distinctly overstates, for individuals differ greatly in their ability to preserve a normal disposition under artificial conditions. The writer of this notice, for example, observed her own dreams, after the method already described, for nearly two months. The work of recording the dreams and their conditions was performed with mechanical, and, so far as possible, with unreflective, accuracy; and the study of the records was not undertaken until the completion of the observations. The result in this case was the record of about two hundred dreams, which were certainly very closely representative of the ordinary dream-life of the observer and noticeably destitute of unusual or abnormal features.

On the other hand, De Sanctis does not sufficiently emphasize the disadvantages of the statistical method which lies at the basis of the greater part of his conclusions. The extreme liability, varying as it does with individuals, to forget one's dreams, throws grave doubt upon the answers of people, untrained in introspection, to questions about the frequency and the vividness of dreams, the emotional nature and the connection with waking experience.

The uncertainty of the inference from bodily motions to the accompanying facts of consciousness, when these cannot be tested by the waking memory of the sleeper, seriously affects the conclusions of the chapter on the dreaming of animals. The discussion of children's dreams, on the other hand, is illuminating and suggestive in so far as it is based upon the author's personal study of the dream-life of his own children. He concludes that children begin to recall their dreams at four or five years of age and he identifies this period with the epoch of the distinct consciousness of self; but he concludes that children actually dream before the years when they recall their dreams, from the fact that characteristic movements in sleep, such as laughter and irregular breathing, which are later proved to accompany dreams, do actually occur before the fourth year.

Only twenty subjects of advanced age were questioned about their dreams, and these confirmed the ordinary statements concerning the infrequency and the colorlessness of the dreams of the aged. The fact that only one of these twenty reviews, in her dreams, the life of her youth, confirms the results of experimental studies in waking association, and shows that old people differ, like younger ones, in their tendencies to recall the distinct periods of their lives; some of them, waking and sleeping, occupy themselves mainly with the past, but others live a life full of present issues.

The chapter on the dreams of adults includes summaries of earlier work on the same line and the results of statistical inquiry comprising answers from one hundred and sixty-five men and from fifty-five women. These figures are too disproportionate in themselves to permit the comparison, which De Sanctis proceeds to make, between the dreams of men and of women. His conclusions, however, while numerically very different from those of Heerwagen, are of the same general nature; he finds (p. 135) that women's dreams are more frequent, more vivid and better remembered than those of men. Like all other investigators he shows also the close connection of dreams with waking experiences.

The discussion of the inquiry which follows—statistical and personal—into the dreams of the mentally deranged is itself too condensed to be readily summarized. Imbeciles and epileptics (except those slightly affected) are found to dream infrequently; hysteric patients, on the other hand, and paranoiac subjects are set down as constant dreamers.

The last of these comparative studies, that

of the dream-life of delinquents, is of especial interest. It is greatly to be regretted that De Sanctis fails to give more exact details of his method of inquiry. Written answers would have been impossible from most of these subjects, so it is probable that the statistics are compiled from personal questioning; and, in this case, it is reasonable to suppose that De Sanctis made his questions concrete enough to secure naïve and reliable answers. A fuller account of his methods should, however, have been given, especially in view of the unequivocal interest of the results (p. 237). Less than one-fourth of the one hundred and twenty-five criminal subjects, and only one-seventh of the class of lowest criminals, are frequent dreamers; whereas one-fourth of the entire number, and two-fifths of the most depraved, are never conscious of dreaming. This suggests, of course, a low degree of mental activity on the part of these subjects, and this indication is strengthened by the observation that by far the greater part of delinquents' dreams are of an entirely unemotional nature. The most curious effect of this tendency is that the criminal seldom dreams of his own crime and when he dreams of it is as likely as not to be entirely unmoved. Twenty-two subjects, out of ninety-three, acknowledged the occurrence of dreams of this character, but half of these stated that such dreams were without emotion.

The emotional nature of the dream is a subject which De Sanctis treats at length, to the comparative disadvantage of such topics as imagery, association and thought in dreams. The chapter on 'Sogni ed Emoziani,' which considers especially the relation of dream-emotions to those of the waking life, is one of the most suggestive of the entire volume. Its chief conclusions are these:

Nearly three-fifths of the normal adult subjects, and many of the hysterical and neurasthenic subjects, have dreams which are distinctly influenced by daytime emotional experiences. Chronic emotions, rather than unexpected and sudden feelings, and emotions of uncertainty, like doubt, suspicion, fear and hope, rather than feelings of settled grief, are reproduced in dreams. And, finally, De Sanctis records his conviction that only emotions of medium intensity are radiated out into the dream-life, since, as he observes, extreme feeling 'consumes force' by the organic excitement which accompanies it. For this reason, and also because suspense rather than certainty marks the dream-feeling, we so seldom dream of the dead at times of recent bereavement.

Cases in which the dream emotion is carried over into the waking life are carefully considered. De Sanctis is of opinion that many cases of the fixed idea and of paranoia are directly traceable to dream experiences, and the extent of his observations lends force to his remark that a suggestion, given for instance in the hypnogogic state, which should effect the dream-life, might indirectly influence the abnormal waking condition.

The experimental observations undertaken by De Sanctis were few in number and are insufficiently reported. The results, such as they are, confirm those of the few published records and of certain unreported experiments of the writer of this notice, all of them tending to show the possibility of artificial modification of the imagery and the emotion of a dream through artificial stimulation. The experimental study of dreams should, however, be widely extended, though the difficulty of accurately reporting the dream experience by the waking memory affects the most important factor of the experimental solution of psychic problems.

De Sanctis briefly summarizes and very justly estimates the physiological theories concerning sleep and dreams. He himself lays stress upon the comparative absence of peripheral stimuli, during periods of cerebral excitation, as at least a sufficient basis for the explanation of the dream experience.

MARY WHITON CALKINS.
WELLESLEY COLLEGE.

### GENERAL.

THE International Institute of Bibliography at Brussels has published a pamphlet discussing the plans of the Royal Society's Catalogue of Scientific Literature. These are criticised somewhat severely, it being claimed that the Royal Society's plans are defective owing to lack of experience in bibliography and the failure to consider catalogues already in operation.

The pamphlet also contains a paper by Professor Ch. Richet on the physiological schedule, and reprints from this JOURNAL Dr. H. H. Field's article on the catalogue.

PROFESSOR ROWLAND'S table of solar spectrum wave-lengths originally printed in the *Astrophysical Journal* has been reprinted in a single volume containing 225 pages, and is offered for sale by the Press Division of the University of Chicago. The table gives the wave-lengths of nearly 20,000 lines measured from photographs made with the concave grating of the Johns Hopkins University.

### BOOKS RECEIVED.

*Descriptive General Chemistry.* S. E. TILLMAN. New York, John Wiley & Sons; London, Chapman & Hall, Ltd. 1899. Pp. x + 429.

*Elementary Studies in Chemistry.* JOSEPH TORREY, JR. New York, Henry Holt & Co. 1899. Pp. viii + 487.

*Insects; Their Structure and Life: A Primer of Entomology.* London, J. M. Dent & Co. Pp. xi + 494.

## SCIENTIFIC JOURNALS AND ARTICLES.

THE *American Naturalist* for August opens with an article by Vernon L. Kellog on 'The Hopkins Seaside Laboratory,' calculated to make Eastern naturalists envious of the advantages enjoyed by their friends on the Pacific coast. J. A. Allen discusses 'The North American Arboreal Squirrels,' in view of Mr. E. W. Nelson's recent revision of the Southern species of the group. William Trelease gives a brief biographical sketch of 'Alvin Wentworth Chapman,' and Thomas H. Montgomery, Jr., continues the 'Synopsis of North American Invertebrates,' with a short account of, and key to, the Gordiaceæ. An interesting account of 'An Abnormal Wave in Lake Erie' is given by Howard S. Reed. There is an unusually large number of reviews of zoological publications, and in the correspondence Dr. Alex Hrdlicka considers 'The Needs of American Anthropologists,' the greatest of which he believes to be the establishment of an Anthropological Institute to form a common, independent center.

*The American Journal of Science* for September contains the following articles:

Gas Thermometer at High Temperatures, by L. Holborn and A. L. Day.

Flicker Photometer, by O. N. Rood.

Quantitative Investigation of the Coherer, by A. Trowbridge.

Double Ammonium Phosphates of Beryllium, Zinc, and Cadmium in Analysis, by M. Austin.

Separation of Iron from Chromium, Zirconium and Beryllium by the Action of Gaseous Hydrochloric Acid on the Oxides, by F. S. Havens and A. F. Way.

Albertite-like Asphalt in the Choctaw Nation, Indian Territory, by J. A. Taff.

Notice of a New Meteorite from Murphy, Cherokee Co., N. C., by H. L. Ward.

Separation of Alumina from Molten Magmas, and the Formation of Corundum, by J. H. Pratt.

IT will be remembered that a department of agriculture for the British West Indian Islands was created last year with Dr. Morris, of Kew Gardens, as Director. We also called attention at the time to the agricultural conference held at Barbados in January. A further step in advance has now been taken by the establishment of a *West Indian Bulletin*, containing a number of articles on the agricultural problems of the islands. Like our agricultural bulletins, it is sent without charge to residents.

## DISCUSSION AND CORRESPONDENCE.

### DARK LIGHTNING.

TO THE EDITOR OF SCIENCE: I have been greatly interested by some photographs showing the rare phenomena of dark lightning, which have recently been sent to me. So far as I know, the only explanation that has ever been offered to account for them is photographic reversal, due to extreme brilliancy. This appears to me to be wholly out of the question for two reasons. In the first place, a dark line on the picture, resulting from over-exposure of a very brilliant line, would be surrounded by bright edges, due to the lesser photographic action in the halation region. This is never present, so far as I know, the dark flashes being minute dark lines ramifying from or in the neighborhood of the main discharge. Secondly, from what evidence I can gather, the dark parts of the flash are not those which appear most brilliant to the observer. Mr. Jennings, of Philadelphia, who in 1890 secured a remarkable picture, reproduced in *Photographic Times Annual* for 1891, showing a very brilliant flash with

countless dark flashes covering the sky around it, tells me that the appearance to the eye was a brilliant white discharge, with fainter rose-colored ramifications, the latter developing in the negative, or rather positive, as dark flashes. Some years ago it occurred to me that a dark flash might be produced by a preponderance of infra-red radiations, which, as Abney has shown, undo the work of ordinary light on the plate. If we had a form of discharge capable of giving off very little actinic light, and an abundance of infra-red light, it might come out dark on a feebly illuminated background. This is, of course, a very wild guess, with nothing to substantiate it, but the dark flash appears to be a reality, and a poor hypothesis is perhaps better than none at all.

I have recently thought that the phenomenon might perhaps be explained in another way. We have a flash which appears darker than the sky behind it. It is inconceivable that the discharge could render the air in its path opaque in the ordinary sense to white light But the light which illuminates the sky in the case of these pictures is not daylight, but light coming from another flash, that is made up of wave-lengths corresponding to the periods of vibration of the dissociated matter in the path of the discharge. Now, may it not be possible that in the dark flash we have a discharge, weak or nearly wanting in actinic light which, however, renders the air in its path capable of absorbing to some extent the radiations of the wave-lengths which come from the bright flash. Such a flash might possibly appear dark on a blackground feebly illuminated by light exclusively of these wave-lengths.

In other words, may we not have in the path of the dark flash, dissociated molecules, radiating but feebly, and capable of taking up vibrations of periods similar to their own, coming originally from a simultaneous brighter discharge?

It might not be impossible to reproduce the phenomenon by photographing a spark in front of a white background in an absolutely dark room. Sparks are almost always taken against a dark background, which would account for the absence of dark flashes in pictures of artificial discharges. A heavy main spark with lateral branches would seem the most suitable kind to employ.

The best method, however, of attacking the problem experimentally, it seems to me, would be a search for selective absorption in a partially exhausted tube. If the source of light were continuous any absorption would be unnoticeable unless it persisted for some time after the discharge (which is unlikely), for the time between successive discharges is very great in comparison to the actual duration of one of them. Even in the case of so-called continuous discharges produced by high potential storage batteries the discharge is often, and may always be, intermittent in character. The source of light should then be of no longer duration than the discharge occurring in the gas, the absorption of which is to be examined.

I can think of no way of producing a white or continuous spectrum source of as short duration as, and contemporaneous with, the discharge in the tube, but by employing two tubes differently excited, the one as a light source, the other as an absorption tube, some results might be obtained. Professor Trowbridge found that an argon tube emitted a blue light or red light, according to whether it was illuminated by means of an oscillatory or non-oscillatory discharge. By using the blue tube as the source and the red tube as the absorption tube, the two being arranged so as to be illuminated simultaneously, it might be found that the red tube had the power of absorbing to some extent the blue radiations from the other. I hardly think results would be obtained, but the experiment seems worth trying.

A picture taken by Mr. H. B. Lefroy, of Toronto, sent to me by Mr. Lumsden, Secretary of the Astronomical and Physical Society of Toronto, has some very curious appearances. There is an exceedingly brilliant flash running down the center of the plate, illuminating the sky quite brilliantly in its neighborhood. In its immediate vicinity, though not joined to it in any way, are innumerable dark, thread-like markings, which in places seem to cross each other, forming meshes.

Mr. Lumsden assures me that the testimony of all photographic experts who have seen the plate is to the effect that markings of that description could only be produced in the exposure ; that is, they are not due to faults in the

film or the results of imperfect development. The fact that they are found only in the immediate vicinity of the bright flash is additional testimony in the same direction. These markings are wholly different from any that I have seen, not having the form of branched flashes. Something in their resemblance to photographs of sound-waves started by a spark, which I have recently made (see *Phil. Mag.* for August) suggested to me that they might possibly be due to the illumination of the sound-wave due to a powerful discharge by a second discharge. Under ordinary conditions, that is with a uniformly illuminated background, such waves would, of course, be invisible, but conditions might possibly arise, due to the proximity of black clouds, under which they might show—a sort of 'Schlieren Methode' on a large scale. I have not attempted yet to plan an arrangement of clouds, which, by acting as screens to light coming from certain directions, might render visible a region of the air, in which the optical density underwent a rapid change. In Mr. Lumsden's picture there are many dark clouds close to the flash. The idea of a photograph of a thunder-wave is a pleasing fancy at all events.

It seems to me that it will be impossible to formulate even a reasonable guess as to the cause of these dark flashes until a good many pictures are gotten together for comparison, and as much testimony as possible secured as to the appearance of the flashes to the eye. Personally, I have seen very few of the pictures and never the original negative.

My intention in writing this letter is not so much to advance theories accounting for the phenomenon of the dark-flash as to re-awaken an interest in the subject and bring out ideas from persons better qualified than I to treat the matter.

R. W. WOOD.

MADISON, WIS.

### A REPLY.

EDITOR OF SCIENCE: The review of my 'Elements of Practical Astronomy' by G. C. C., in SCIENCE for June 16th, criticises adversely some eight or ten small points. In so far as the article expresses the reviewer's individual opinions, there is no call for a reply, since that is the prerogative in which a critic should be protected. But I venture to say that the reviewer's zeal has led him unconsciously to make several erroneous statements.

In answer to the reviewer's remark: "Throughout his entire work the author appears to have ignored the advantage offered by addition and subtraction logarithms," I respectfully refer him to page 50, where both addition and subtraction logarithms are employed, and to the statement, p. 243: "If two quantities are given by their logarithms, and the logarithm of their sum or difference is required, it should be found by means of addition and subtraction logarithms." This covers the whole case.

The reviewer regrets that the book gives up '4% to diurnal parallax as affected by the earth's compression.' Such is not the case. Less than 2% is devoted to this subject, and in reality only about 1%, if we deduct the space demanded for the substitute treatment of the earth regarded as a sphere. Besides, the inclusion of this subject is imperative, unless, indeed, we exclude observations of meteors, the moon and any other near-at-hand bodies. Is G. C. C. willing to send out students of Practical Astronomy ignorant of the fact that there can be a parallax in azimuth? His criticism means just that.

The formula expressing the rate of a chronometer, p. 160, criticised in all seriousness by G. C. C., will meet his requirements if we replace the missing exponent 2 over the parenthesis—the only omission of the slightest consequence yet brought to my notice in the more than 400 equations. This formula is as fundamental in dealing with a chronometer as $\sin^2 + \cos^2 = 1$ is in Trigonometry, and should give a reviewer no trouble.

The reviewer refers to a well-known method of computing the azimuth, p. 199, and curiously enough misses the whole point of the method. He suggests another method—also well known—which in practical use is actually longer, with the added disadvantage of requiring two kinds of logarithms in the same solution. It is true that one solution by the first method requires 21 entries on the computation sheet (all the quantities being recorded), whereas the substitute

requires only 15 entries. But in this problem it is the custom to make several solutions in succession, in parallel columns; and in all columns after the first the criticised method requires fewer entries than does the suggested substitute. The reviewer's failure to see the point is all the more surprising, since, on the same page, alongside the first column, is a second column, in which only 10 entries are required. In fact, if no unnecessary recording is done, five entries are sufficient.

And most teachers of 'Practical Astronomy' will agree in my opinion that the wider publication of addition and subtraction logarithms has not done away with the desirability of 'adapting formulæ to logarithmic computation.' The solution of most problems is actually shortened by transforming the equations so that such logarithms are not needed. These logarithms were well known to Chauvenet, were referred to by him, and he made it clear (Vol. I., p. 211) when they should be used. In the class of problems we are considering, their wider publication has not influenced the form of solution appreciably with many astronomers, nor does it deserve to, for valid reasons. Take the case most strongly criticised by G. C. C.—that of determining the hour angle $t$ from a measured altitude. I have—on five different pages—equally recommended using the well-known forms $\tan \frac{1}{2} t$ and $\sin \frac{1}{2} t$. I understand, and every reader of the criticism will understand, that G. C. C. would entirely replace these by the well-known form $\cos t$, not only in the example solved by me, but in all such solutions. A solution through $\tan \frac{1}{2} t$ requires 17 entries, but this method is the most accurate and most generally applicable of the three. Slightly less accurate and general is the solution through $\sin \frac{1}{2} t$, which requires 14 entries; and this is the form most frequently used by astronomers. The solution through $\cos t$ requires 13 entries, besides the use of two kinds of logarithms, and has the further disadvantage that it is less general than the other two forms. In fact, $\cos t$ should not be used at all if $t$ is less than 30°; and the observer's position, combined with clouded skies, will often make observations under such conditions desirable. There are many astronomers, of the greatest experience, who would not use the $\cos t$ formula when $t$ is less than 45°; they would employ the forms $\sin \frac{1}{2} t$ or $\tan \frac{1}{2} t$ in preference. To save one or two entries at the expense of accuracy and generality of the formulæ, strikes me as being poor astronomy and poor pedagogy.

It is plain that the reviewer regrets the insertion of an Appendix containing the principal 'Formulæ Resulting from the Method of Least Squares,' 'with no pretense at their derivation.' The Method of Least Squares is not a branch of Astronomy, any more than are Trigonometry and Logarithms. It is a method employed in all the sciences where quantitative observations are made. The formulæ used in applying the method have been appended for ready reference, and have been found convenient. There is no longer any practical reason for including a chapter on this subject, since several small text-books on Least Squares are available. There is one of some 60 pages written by a gentleman whose initials are G. C. C. (presumably the reviewer)—it is called a 'Treatise'—in which *the one fundamental equation of the subject is assumed*, 'with no pretense at its derivation.'

The reviewer objects to devoting $2\frac{1}{2}$ % "of the entire treatise to such an antiquated matter as lunar distances." As I explained in the book, this method "is occasionally of considerable importance to navigators and explorers." It is sufficient to say that the French *Connaissance des Temps* devotes about 5 % of its space, the British *Nautical Almanac* about 11 % and the American *Nautical Almanac* more than $13\frac{1}{2}$ % to the data for solving this problem.

Likewise, the objectionable $1\frac{1}{2}$ % devoted to the ring micrometer is introduced with the statement that results obtained with it "can be regarded as only approximately correct, and the ring micrometer should never be used with an equatorial telescope unless, in case of great haste, there is not time to attach the filar micrometer and adjust its wires by the diurnal motion;" and further "that it can be used with an instrument mounted in altitude and azimuth, * * whereas a filar micrometer cannot." These remarks cover the entire case, and it is impossible that they should mislead a student.

The reviewer has called attention to a real

error on p. 75, which I beg leave to acknowledge. By neglecting differential refraction in the determination of the value of a revolution of a micrometer screw (in the second of the three methods proposed) an error of about one part in 3,600 is introduced. That is, if the value of a revolution is 18″, the effect of neglected refraction is 0″ .005.

Again, by a slip of the pen, p. 43, the author is made to say that "*In all cases* the refraction must be applied first." There is one exception that, in altitudes measured from the sea horizon, the correction for dip should be applied previous to the correction for refraction.

My statement concerning the surveyor's transit, that the time, latitude and azimuth "can easily be determined to an accuracy within the least readings of the circle" is the literal truth, so far as the methods given by me are concerned. I have not attempted to get everything possible out of the surveyor's transit, and why should I? If great accuracy is required, instruments and methods specially adapted to the solution of the problem, and described in the earlier chapters of the book, will be employed. Why should an astronomer make a fad of a surveyor's transit when he has an observatory full of instruments which will do his work better? No further explanation is needed for the reviewer's remark that the surveyor's transit 'has been strangely neglected by astronomers.' W. W. CAMPBELL.

The reviewer, after careful consideration of Professor Campbell's remarks printed above, finds no reason to modify any of the opinions expressed in the review. G. C. C.

### FOEHN WINDS.

TO THE EDITOR OF SCIENCE: In connection with Professor Wilson's communication on Foehn Winds in SCIENCE for August 18th, I beg to say that the word *foehn* was misspelled *foehm* in the proof sent me from the publication office of this JOURNAL. I made the necessary corrections in the proof, but for some reason the final *m* was left standing, instead of being replaced by the *n*. Being away from Cambridge at the time, I did not notice the mistake in the final printing of my note (in SCIENCE for July 21st) until a few days ago, and hence it happened that Professor Wilson anticipated me in making the necessary correction. R. DEC. WARD.

HARVARD UNIVERSITY, DEPARTMENT OF GEOLOGY AND GEOGRAPHY.

### SCIENTIFIC NOTES AND NEWS.

THE University of Mississippi has conferred the degree of LL.D. on Dr. Eugene A. Smith, of the University of Alabama.

THE following appointments under the Department of Agriculture are announced: Mr. W. A. Orton, of the University of Vermont, Assistant in the Division of Vegetable Physiology and Pathology, and Mr. Hermann von Schrenk, Special Agent in this division: Messrs. C. R. Ball, E. D. Merrell and P. B. Kennedy Assistants in the Division of Agrostology.

DR. W. PFEFFER and Dr. Zirkel, professors of botany and of mineralogy, respectively, at Leipzig, have been elected foreign members of the Accademia dei Lincei, of Rome.

THE Académie Internationale de Géographie Botanique has conferred its international scientific medal upon Professor John M. Coulter, of the University of Chicago.

PROFESSOR G. H. HOWISON, of the department of philosophy of the University of California, and Professor Irving S. Stringham, of the department of mathematics, will spend the coming academic year abroad.

PROFESSOR A. C. ARMSTRONG, JR., who holds the chair of philosophy in Wesleyan University, will be abroad during the coming year.

PROFESSOR J. MARK BALDWIN has been given a half year's leave of absence from Princeton University to see the *Dictionary of Philosophy and Psychology* through the press in England. He intends to sail on September 19th and wishes all the American contributions, proofs, etc., to be in his hands in the first week of September. His London address is care Messrs. Macmillan & Co. His courses at Princeton will be in the hands of Professor H. C. Warren.

THE funeral of Sir Edward Frankland took place at Reigate on August 22, the services being conducted by the eminent geologist Professor Bonney. Among those present were Lord Lister, Sir Frederick Bramwell, Sir Henry

Roscoe, Sir Michael Foster, Dr. Ludwig Mond and Dr. Thorpe.

A REUTER dispatch from Liverpool states that, in consequence of the important discovery by Dr. Ronald Ross of the malarial mosquito, and the need of another man of science to be sent out immediately to Sierra Leone, the Liverpool School of Tropical Diseases has just selected Dr. Fielding Ould for this purpose. Dr. Fielding Ould, who has been much engaged in private research in connection with the Liverpool School of Pathology, has been specially trained by Professor Boyce, of the Liverpool University, in the study of tropical diseases. Dr. Fielding Ould had arranged to leave Liverpool for Sierra Leone by the Elder-Dempster steamer *Biafra* on Saturday, September 2.

WE have already had occasion to state that the National Physical Laboratory, which will probably do for England what the Reichsanstalt does for Germany, was established through the efforts of the British Association for the Advancement of Science and is placed under the direction of the Royal Society. A further use of scientific societies is made by permitting six of the twelve elected members of the Council to be nominated by the great technical societies—the Institutions of Civil, Mechanical, Electrical and Naval Engineers, the Iron and Steel Institute and the Society of Chemical Industry. It is extremely important that our scientific societies should take action that will lead to the establishment of a national physical and chemical laboratory at Washington. A government which accomplishes so much for science as the United States should not neglect a field which Germany has shown to be so important to its industrial interests and on which Great Britain has now entered.

THE British Medical Association will meet next year at Ipswich under the presidency of W. A. Elliston.

A COMMISSION has been appointed to enquire into the inland fisheries of Ireland. The scientific members are Dr. D. J. Cunningham, professor of anatomy in Trinity College, Dublin, and Dr. W. C. Macintosh, professor of natural history in the University of St. Andrews.

PROFESSOR W. E. RITTER, of the University of California, has returned from a biological expedition to Alaska, where he has been making collections for the University.

THE Bavarian government has granted $1,500 to Dr. Karl Giesenhagen, for a tour through the unexplored interior of Malacca.

THE Austrian explorer, Dr. H. Leder, who visited the ruins of Kara-Korum in 1892, is again in Central Asia, and writes that he has good prospects of reaching Lhasa, with the aid of the ruler of Urga. He intends to join one of the large caravans that go from Urga to the residence of the Dalai Lama.

SIR EDMUND ANTROBUS, owner of Stonehenge, the famous monument on Salisbury Plain, England, has offered to sell it, together with 1,300 acres of adjacent land, to the British government, for £125,000.

IN the prosecution of the general magnetic survey of the United States and countries under its jurisdiction by the Coast and Geodetic Survey, it will be necessary at times, and especially during the summer months, to employ temporarily and for short periods a number of men of the requisite scientific training. Persons are desired who have had experience in a university in physics or allied sciences; or persons who have taken post-graduate degrees in physics or allied sciences; or students who have had not less than two years' work in physics or allied sciences, including laboratory practice. There will be no educational examination for these positions, but applicants will be graded upon their training and experience, and will be required to file their applications with the Civil Service Commission prior to October 1, 1899, in order to have their names entered upon the register which will be prepared immediately after that date. The salaries for these positions will range from $30 to $75 a month, according to the character of the work and the qualifications of the applicant; and in exceptional cases, where the person employed has had repeated experience in magnetic work, the salary may reach $100 per month.

THE Civil Service Commission also wishes to fill the position of electrical engineer in the Treasury Department at a salary of $1,400 per

annum. The examination will be held on September 17th, 18th and 19th.

LORD KELVIN writes to *Nature* from Aix-les-Bains under the date of August 7 as follows: "Last night, during a thunderstorm of rare severity in which brilliant flashes—single, double, triple or quadruple—followed one another at intervals often of not more than a few seconds of time, I was surprised to see, with great vividness, on a suddenly illuminated sky, two nearly vertical lines of darkness, each of the ordinary jagged appearance of a bright flash of lightning. I remembered to have seen two real flashes of just the same shapes and relative positions, and I concluded that the black flashes were due to their residual influence on the retina. I turned my eyes quickly from the dark sky outside to an illuminated wall inside the house, and I again saw the same double dark 'flash,' which verified my conclusion in an interesting manner. The fatigued part of the eye failed to perceive the brightness of the sky in the one case and of the wall in the other."

IN the course of an interview with Signor Marconi, a press representative obtained some information with reference to the arrangements for the wireless telegraphy demonstrations at the forthcoming meeting at Dover of the British Association. The headquarters of the British Association will be at the Town-hall, and it is here that the French and English scientific visitors are to have the opportunity of witnessing some wireless telegraphy experiments. Signor Marconi had just returned from the naval manœuvres, and planned to leave for America at the beginning of September. He would, however, superintend all the necessary arrangements for his demonstrations at the British Association. During the meeting these demonstrations will be left in charge of Professor Fleming, of University College, London. Messages of congratulation will probably be exchanged between Dover and different parts of Europe. Signor Marconi said that the trials between Dover Town-hall and the lighthouse at St. Margaret's had been a complete success, the tests applied yielding the most satisfactory results. Asked as to whether an attempt would be made to send messages direct between Dover Town-hall and Boulogne, Signor Marconi said this would depend upon circumstances. The installation at Wimereux, near Boulogne, is the property of the French government. It was possible to send direct communications, but certain alterations on the French side of the Channel would be necessary. As the French Association for the Advancement of Science would be holding its annual conference at Boulogne at the same time as the British Association at Dover, and as both societies would be cooperating together and exchanging courtesies, he thought there should be no difficulty in obtaining the necessary consent of the French government. Otherwise messages will be sent across the Channel between Dover and Boulogne *via* the South Foreland. Signor Marconi referred to the demonstrations with wireless telegraphy made during the recent naval manœuvres. The results of these demonstrations, he stated, had established the fact that, even with the present installation at the South Foreland lighthouse, messages could be exchanged with a fleet as far down the Channel as Cherbourg, a distance of about 100 miles, and even farther.

THE London *Times* states that several members of the expedition organized by Mr. Claude Beddington for scientific and geographical research in West Africa have returned to England. The route followed by the explorers lay through the *Hinterland* of the Gold Coast, the neutral zone (the delimitation of which is now the subject of diplomatic negotiation), and the *Hinterland* of the German colony, Togoland. Many districts hitherto unvisited by Europeans were traversed, and several new and interesting entomological specimens have been the result of the explorer's enterprise. The big game encountered included elephant, buffalo, hippopotamus and many rare species of antelope. Mr. Beddington was much struck with the enterprise shown by the German government in Togoland, where well-constructed roads and substantial government buildings, the result of large Imperial grants, form a striking contrast to the condition of things in the British territory. Among other industries encouraged by the German authorities is the planting of

kola trees, which should be a source of future wealth to the colony, as the kola nut seems to be almost an essential stimulant to every Hausa, and it is at present imported at great expense from Ashanti, where it is indigenous. The members of the expedition suffered from the usual malarial fever, but fortunately not to such an extent as to incapacitate them from much useful scientific work.

A RECENT issue of the *British Medical Journal* gives an abstract of the report of the Principal Chemist of the Government Laboratory for the year ending March 31, 1899, which has been issued as a Parliamentary paper. The number of samples of butter examined was 1,083, and only two were reported adulterated, as against 25 last year and 46 the year before. Experiments made at Wye and in the laboratory are held to have proved beyond doubt that the characteristic constituent of cotton-seed oil passes into the milk of cows fed upon cotton cake. Certain samples of butter examined during the year gave reactions for cotton seed oil, but the amount indicated was held to be not more than might be due to feeding on cotton cake. The Danish and Scandinavian butters examined were entirely free from boric preservatives, but those from France, Holland, Australia and New Zealand contained such preservatives. The use of coloring matters derived from coal tar seems to be most prevalent in the United States, but is also met with in samples from Holland. The majority of the margarines contained cotton-seed oil, boric preservative and aniline coloring matters. Samples of cream imported from Holland, Denmark, Norway and Sweden were examined at the instance of the Local Government Board, and all found to be genuine. The laboratory also made a number of analyses in connection with the Home Office inquiries into the use of lead in pottery manufacture, and phosphorus in the manufacture of lucifer matches. Among the samples of food substances from various canteens examined for the War Department many proved to be of low quality. A number of medicinal preparations were examined for the Army Medical Department, and in several instances were found to be markedly inferior to the standards of the *British Pharmacopœia*.

## *UNIVERSITY AND EDUCATIONAL NEWS.*

THE late Madame Halfon has bequeathed £1,600 to University College, London, for the foundation of two prizes.

A DINNER will be held at the end of November in aid of the fund to provide new laboratories for King's College, London. The Hon. A. J. Balfour will preside.

THE chair of botany at Yale University held by the late Daniel C. Eaton is hereafter to be known as the Eaton professorship of botany. The chair was endowed for Professor Eaton, but we believe not largely, and it is to be hoped that the corporation will appropriate the funds necessary to secure the services of a representative botanist.

PROFESSOR W. M. WHEELER, assistant professor of embryology in the University of Chicago, has been elected professor of zoology in the University of Texas. His address after September 15th will be Austin, Texas.

PROFESSOR J. L. KELLOGG, of Olivet College, Michigan, has been elected assistant professor of biology at Williams College, Williamstown, Mass.

ARTHUR ST. C. DUSTAN, associate professor of physics, University of Kansas, has been elected professor of physics and electrical engineering in the Alabama Polytechnic Institute, Auburn, Ala., in the place of Professor A. F. McKissick, who has resigned.

WALTER W. DAVIS, of the Psychological Laboratory of Yale University, has been appointed professor of physical culture and Director of the Gymnasium at Grinnell College, Iowa.

DR. RICHARD STOERNER, docent in chemistry in the University at Rostock, has been promoted to an assistant professorship.

THE following have qualified as docents in German universities: Dr. Behn, in physics in the University of Berlin; Dr. Neumann, in applied mathematics, and Dr. Grassmann, in mathematics in the University at Halle; Dr. V. Schmeidler, in physics, and Dr. Figdor, in plant anatomy and physiology, in the University of Vienna.